DRAFT

AIR QUALITY ASSESSMENT

NORTH-SOUTH SECTION

RED HILL CREEK EXPRESSWAY

HAMILTON, ONTARIO

RWDI

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HAMILTON, ONTARIO

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Companion Studies: Vehicle Air Emissions Inventory

Traffic Noise Impact Assessment

Thermal Dynamics Assessment

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EXECUTIVE SUMMARY

Rowan Williams Davies & Irwin (RWDI) was retained by the Regional Municipality of Hamilton-Wentworth to conduct an air quality assessment for the North-South Red Hill Creek Expressway. This section would complete the linkage between the existing East/West Section, which runs along the top of the Niagara Escarpment and the Queen Elizabeth Expressway.

An earlier air quality assessment in 1989, assuming a number of worst-case assumptions, predicted high impact zones for particulate matter. A number of improvements in the emissions and dispersion models led to this updated and more detailed air quality assessment.

The air quality assessment was carried out using the PART5 and MOBILE5C emissions models and CAL3QHCR dispersion model. Reasonable worst-case scenarios were developed. The study scenario included peak PM traffic volumes for the year 2010, one year of meteorological data from the MOE's Woodward Avenue Station in Hamilton and ambient background pollutant concentrations. The pollutants studied were carbon monoxide (CO), nitrogen oxides (NO_x) and inhalable (PM10) and total suspended particulate matter (TSP). The results of the analysis indicated that predicted levels of CO and NO_2 were predicted to be less than their applicable 1-hour criteria; however, PM10 and TSP concentrations are expected to exceed their 24-hour criteria. In general, exceedences of the PM10 and TSP criteria were predicted to occur up to about 200m from the travelled roadway surface.

When compared to ambient air quality measurements taken adjacent to comparable roadways, the predicted levels were found to be overestimated when compared to ambient measurements from the 1995 Highway 404 survey, predicted maximum 1-hour concentrations of CO and NO_x were overestimated up to two times. Predicted levels of PM-10 and TSP were found to be overestimated by factors of about 3 and 4, respectively.

Mitigation measures such as wet sweeping and flushing of the roadway surface are recommended.

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1. INTRODUCTION

The Regional Municipality of Hamilton-Wentworth (Region) conducted a multi-year, environmental assessment process for the Red Hill Creek Expressway (RHCE) in the 1980's. Included in that process was an assessment of the air quality impacts from vehicular traffic. Rowan Williams Davies and Irwin Inc. (RWDI) completed the assessment study and produced a Report Number #89-320-6 and dated October 26, 1989 [1]. This report evaluated the entire Mountain Transportation Corridor which included the East/West Section (now in operation and called the "Linc") and the North-South Section.

This report outlines an updated assessment of the air quality impacts from the North-South Section. A number of improvements in the emissions and dispersion models, and changes in the roadway alignment, traffic volumes and several other factors have led to the need for this updated study. The Region filed an application for an Exemption Order to the Ontario Ministry of the Environment on May 6, 1996. It contains the details of the terms of reference for this study.

The objectives of this study are three-fold:

(1) establish existing atmospheric conditions in the valley;

(2) to assess the impact of vehicular emissions from the proposed RHCE North-South Section on the local air quality; and

(3) where high impact areas are indicated, suggest mitigation measures to alleviate the impacts.

1.1 Key Findings

The key findings of this study are:

- although some progress has been made in improving the air quality in Hamilton in recent years, levels of dust, both total suspended particulate (TSP) matter and inhalable particulate matter (PM10), remain high;

- maximum predicted 1-hour CO and NO_2 concentrations are not expected to exceed the applicable ambient air quality criteria; and

- maximum predicted 24-hour TSP and PM10 levels are expected to exceed the applicable ambient air quality criteria at downwind distances up to about 200m from the roadway.

1.2 Glossary of Terms and Abbreviations

A number of scientific terms and abbreviations are used in this report. The following summarises key meteorological terms. Appendix A contains definitions for a number of air quality terms.

Meteorology

The dispersion of pollutants emitted into the atmosphere is affected by a number of meteorological parameters, the most important of which are explained as follows:

Wind is characterized by both its speed and direction. The wind speed determines the rate at which dilution of emissions occurs as well as the rate at which the polluted air parcel moves from the source area. The wind direction determines the direction of the air parcel trajectory away from the source area.

Stability of the atmosphere has been characterized by the relative roles of mechanical and buoyant processes on the turbulent mixing of the air. Mechanical turbulent processes are defined by the nature of the surface roughness and the strength of the wind, while buoyancy is characterized by air density differences in the atmosphere as measured by the rate of change of air temperature with height. The resulting atmospheric stability determines the rate at which turbulent diffusion spreads, and therefore dilutes through mixing, the polluted air parcel in the horizontal and vertical directions.

Mixing height is characterized by the depth of the atmosphere which is convectively unstable. Under convective conditions in the planetary boundary layer, the air is well mixed principally due to large eddies generated by surface heating to the mixing height. Thus, the mixing height generally evolves from a depth close to the surface in the morning to a maximum height by mid-afternoon dependent upon the degree of surface heating due to solar radiation. The mixing height is an important constraint to the dispersion process in the vertical direction for emissions released within the depth of the boundary layer. Emissions released above the mixing height depth are generally uncoupled from the processes within the layer.

Other weather parameters such as cloud cover, atmospheric pressure and air temperature indirectly affect the dispersion process through their influence on the wind, stability or mixing height. Rainfall and snowfall may also be important parameters as a result of their ability to remove (i.e., dust) or transform the emitted pollutants. Topographical influences also may play a part in the dispersion climate of an area. Terrain features such as hills, valleys and large lakes may affect the dispersion of emissions in a number of ways. All of these features are present in the study area.

2. GUIDELINES

2.1 Ministry of Environment Air Quality Guidelines

The Ontario Ministry of the Environment has developed many ambient air quality criteria for pollutants which are typically emitted from traffic and which are known to have harmful effects on human health or have the potential to cause degradation to the environment. The major pollutants of concern which are related to vehicular traffic include carbon monoxide (CO), nitrogen oxides (NO_x), hydrocarbons and particulate matter (PM).

Ambient air quality criteria (AAQC) have been established by the MOE for numerous contaminants. Regulation 337 establishes several hundred desirable ambient air quality guideline levels [2]. Table 1 outlines the AAQC's for contaminants relevant to vehicular traffic and the proposed development of the North-South Section of the Red Hill Creek Expressway.

Table 1: Summary of Relevant Ontario Ambient Air Quality Criteria in ppm (ug/m^3)

Contaminant	1-hour	8-hour	24-hour	Annual
CO	30 (36,200)	13 (15,700)	N/A	N/A
NO*				
NO_2	0.20 (400)	N/A	0.10 (200)	N/A
NO_x*				
TSP	N/A	N/A	120	60^+
PM10	N/A	N/A	50**	N/A
VOC***				
PAH***				

Notes: N/A - Not Applicable.
* AAQC do not exist.
** Interim AAQC only.
*** Different AAQC exist for individual species.
$^+$ Geometric mean.
Source: References 1 through 6.

3. EXISTING ATMOSPHERIC ENVIRONMENT

The atmospheric environment near the expressway can be defined in terms of existing or background air quality levels and also the dispersion climatology. To date, no long-term air quality or meteorological measurements have been carried out in the area. A six month ambient air quality survey was commissioned in mid-December 1997. RWDI installed an ambient air quality monitoring station at the corner of Mount Albion Road and King Street. Some details from this survey are given below along with historical results from other select MOE stations across the Region. Meteorological data has also been compiled from the MOE tower at Woodward Avenue.

3.1 Ambient Air Quality Monitoring

In an effort to document and control pollutant emissions, air quality monitoring is frequently used to determine ambient levels, establish trends and as a tool for assessing the effectiveness of mitigation strategies in problem areas. Numerous MOE monitoring stations have been in place in the Hamilton area for many years. The table attached to Figure 1 presents select MOE stations which are operated in the general vicinity of the proposed highway development and/or provide typical urban air quality readings. Other MOE monitoring stations exist throughout the Region, but are either too far away from the proposed development to provide representative data or do not account for emissions relevant to road traffic. Figure 1 illustrates the proposed North-South Section of the Red Hill Creek Expressway and the location of the relevant MOE monitoring stations. Historical data from these monitoring stations assist in our understanding of typical pollutant levels in the region.

The following sections briefly outline historical ambient pollutant levels at specific MOE monitoring stations. Information contained within the following sections has been summarized from data contained within MOE air quality publications for stations in the Region [3, 4, 5, 6, 7, 8].

The tables presented in the following sections summarize several years of ambient data collected from select MOE monitoring stations. Maximum 1-hour, 8-hour and 24-hour values are provided and represent the maximum pollutant level which was recorded in the respective time period during the specified year. The arithmetic mean represents the average recorded value; the 99th percentile value represents the level for which 99 percent of the readings are equal to or below; and the geometric mean represents the 50th percentile value.

3.1.1 Carbon Monoxide

Carbon monoxide (CO) is a colourless, odourless, tasteless and poisonous gas which is produced as a result of incomplete combustion. The primary source of CO within Hamilton is from the transportation sector [3]. Exposure to elevated levels of CO is associated with impairment of visual perception, work capacity, learning ability, and performance of complex tasks. The Ontario ambient air quality criteria for CO is 30 ppm (36,200 ug/m^3) based on a 1-hour average and 13 ppm (15,700 ug/m^3) based on an 8-hour average.

Table 2 presents data which has been collected from MOE monitoring stations for CO. The arithmetic mean is a good indicator of annual trends and indicates that CO levels have generally decreased for the last four years of reported data. No exceedences of the 1-hour or 8-hour criteria occurred.

Table 2: Summary of Measured Ambient Carbon Monoxide Statistics for 1990-1995 at Elgin/Kelly Station (#29000) (in ppm)

Statistic	1995	1994	1993	1992	1991	1990
1-hr Max	6	7	9	6	8	7
8-hr Max	4	3	4	4	4	6
Arithmetic Mean	0.6	0.8	1.1	1.2	1.1	1.2
99th Percentile	n/a	1.9	2.7	2.9	2.2	2.8

Notes: 1-hour AAQC is 30 ppm.
8-hour AAQC is 13 ppm.
Source: References 3 through 8.

3.1.2 Nitrogen Oxides

Total nitrogen oxides (NO_x) are the sum of nitrogen dioxide (NO_2) and nitric oxide (NO), both of which are emitted from automobiles. NO contributes about 70% to 90% of NO_x emissions from automobiles. NO_x contributes to haze and visibility reduction and is also known to cause deterioration to certain fabrics and damage vegetation. NO_2 is a reddish brown gas with a pungent and irritating odour and is responsible for increasing sensitivity to individuals with asthma and bronchitis. NO_2 also reacts with hydrocarbons in the presence of sunlight to form ozone and with water to form nitric acid. There are two AAQC's for NO_2 including 0.20 ppm (400 ug/m^3) based on a 1-hour average and 0.10 ppm (200 ug/m^3) based on a 24-hour average.

NO is a colourless and odourless gas which reacts with ozone to form NO_2. Direct effects of NO on health and vegetation at ambient levels are not known. No criteria exist for either NO_x or NO. A summary of the data collected at MOE stations for NO_2 and NO_x are presented in Tables 3 and 4, respectively.

Annual averages of NO_2 show that levels remained very stable throughout the six-year time period at both stations 29000 and 29114. There were no exceedences of either the 1-hour or 24-hour NO_2 criteria at either station. Although criteria do not exist for NO_x, it can be seen that annual averages have increased in the past 3 years; whereas, NO_2 levels have decreased somewhat.

Table 3: Summary of Measured Ambient Nitrogen Dioxide Statistics for 1990-1995 (in ppm)

Statistic/MOE Station ID Number	**1995**	**1994**	**1993**	**1992**	**1991**	**1990**
1-hr Max						
29000	0.08	0.12	0.1	0.07	0.11	0.09
29114	0.07	0.09	0.1	0.09	0.07	0.08
24-hr Max						
29000	0.05	0.06	0.06	0.05	0.07	0.05
29114	0.04	0.05	0.06	0.05	0.04	0.05
Arithmetic Mean						
29000	0.019	0.022	0.022	0.019	0.022	0.022
29114	0.015	0.018	0.018	0.017	0.019	0.016
99th Percentile						
29000	n/a	0.055	0.06	0.045	0.056	0.05
29114	n/a	0.048	0.058	0.048	0.047	0.048

Notes: 1-hour AAQC is 0.20 ppm.
24-hour AAQC is 0.10 ppm.
Station #29000 is Elgin/Kelly
Station #29114 isVickers/East 18th

Source: References 3 through 8.

Table 4: Summary of Measured Ambient Nitrogen Oxides Statistics for 1990-1994 (in ppm)

Statistic/MOE Station ID	1994	1993	1992	1991	1990
1-hr Max					
29000	0.52	0.49	0.37	0.5	0.55
29114	0.48	0.32	0.28	0.32	0.34
24-hr Max					
29000	0.24	0.2	0.13	0.16	0.21
29114	0.11	0.14	0.1	0.1	0.19
Arithmetic Mean					
29000	0.04	0.039	0.033	0.033	0.035
29114	0.028	0.027	0.024	0.03	0.027
99th Percentile					
29000	0.205	0.207	0.173	0.158	0.178
29114	0.128	0.148	0.114	0.134	0.142

Notes: No AAQC exists for NO_x.
Station #29000 is Elgin/Kelly
Station #29114 is Vickers/East 18th

Source: References 3 through 8.

3.1.3 Particulate Matter

Particulate matter (PM) is a generic term referring to small airborne particles including dust, mist, aerosols, smoke, fumes and soot. Motor vehicles directly emit particulate matter out of the exhaust and brakes and, more significantly, are also responsible for entraining road dust into the atmosphere. Particulate matter significantly affects people with lung disease, asthma or bronchitis and can damage vegetation, contaminate soil and decrease visibility. Suspended particulate matter includes particles up to about 44 microns in diameter. The Ontario criteria for TSP is 120 ug/m^3 (24-hour average) and 60 ug/m^3 (annual geometric mean).

Particles which are less than 10 microns in diameter (PM10) are of particular importance. PM10 is known to penetrate into the respiratory tract and is mainly associated with health effects. An interim criteria for PM10 has been set at 50 ug/m^3 (24-hour average). Tables 5 and 6 summarize data for TSP and PM10, respectively, from select MOE stations in the Region.

Table 5 indicates that several exceedences of the 24-hour criteria for TSP occurred at many monitoring stations during the years 1990 to 1995. Tables 6a and 6b indicate that readings in excess of the interim 24-hour criteria for PM10 have occurred but a frequency can not be established. These findings are largely attributable to the industrial sector of Hamilton, rather than transportation, and are not uncommon in regions of high industrial activity [3].

Table 5: Summary of Measured Ambient Total Suspended Particulate Matter Statistics for the period, 1990-1995 (in ug/m^3).

Statistic/MOE Station ID Number	1995	1994	1993	1992	1991	1990
24-hr Max						
29000	***158*** (7)	***204*** (9)	***203*** (9)	***209*** (7)	***164*** (5)	***209*** (11)
29113	***230*** (24)	***157*** (11)	**240 (15)**	***335*** (7)	157 (7)	***246*** (9)
29114	***127*** (2)	83	***136*** (2)	***126*** (2)	***128*** (2)	112
29119	***242*** (21)	***152*** (8)	***157*** (5)	***210*** (7)	***165*** (18)	***157*** (20)
29135	90	81	110	***122*** (2)	***266*** (2)	119
29143	***212*** (10)	***138*** (5)	***130*** (2)	-	-	-
Annual Geometric Mean+						
29000	51	60	53	59	***61***	***64***
29113	***85***	***71***	***63***	***71***	***68***	***73***
29114	52	39	40	37	45	41
29119	***80***	***72***	59	***63***	***78***	***78***
29135	38	33	32	33	37	36
29143	***65***	59	58	-	-	-
Arithmetic Mean						
29000	n/a	67	61	66	66	72
29113	n/a	77	75	80	72	81
29114	n/a	42	46	41	50	46
29119	n/a	77	65	69	86	86
29135	n/a	36	37	37	44	41
29143	n/a	65	63	-	-	-
99th Percentile						
29000	n/a	***175***	***160***	***202***	***146***	***205***
29113	n/a	***153***	***232***	***280***	***157***	***230***
29114	n/a	79	***122***	108	***123***	107
29119	n/a	***143***	***136***	***203***	***163***	***155***
29135	n/a	70	101	111	***159***	115
29143	n/a	***129***	***125***	-	-	-

Notes: 24-hour AAQC is 120 ug/m^3.
Annual AAQC is 60 ug/m^3.
Bold, italicized values have exceeded the AAQC.
Values in brackets are the number of times the AAQC were exceeded for that year.
+ As the geometric mean is calculated on an annual basis, only one event can occur in a given year.

Source: References 3 through 8.

Table 6a: Summary of Maximum Measured Ambient PM10 Statistics for 1994-1995 from Continuous Monitoring at Station 29000 (in ug/m^3).

Statistic	1995	1994
1-hr Max	554	684
24-hr Max	*127*	*157*
Arithmetic Mean	29	27

Notes: Interim 24-hour AAQC is 50 ug/m^3.
Italicized values have exceeded AAQC but a total number of events was not specified by MOE.

Source: Reference 3.

Table 6b: Summary of Measured Ambient PM10 Statistics for 1992-1995 from Hi-Vol Sampling (in ug/m^3)

Statistic/Station ID Number	1995	1994	1993	1992
24-hr Max				
29300*	***88***	***96***	***97***	***80***
29313**	***88***	***90***	***104***	***110***
Geometric Mean				
29300*	20	26	22	26
29313**	33	34	26	32
Arithmetic Mean				
29300*	24	30	27	29
29313**	37	37	33	35

Notes: Interim 24-hour AAQC is 50 ug/m^3.
Bold, italicized values have exceeded AAQC but a total number of events was not specified.
* Station 29300 is same location as Station 29000.
** Station 29313 is same location as Station 29113.

Source: Reference 3.

Based on three years of ambient readings (1993-1995) from a number of MOE stations in the Region, a ratio of PM10 to TSP was calculated. Using the geometric means, a ratio of 0.42 was found.

3.1.4 Hydrocarbons

Hydrocarbons are generally defined in terms of s volatile organic compounds (VOC's) and semi-volatile compounds (SVOC's). Polycyclic aromatic hydrocarbons (PAH's) are the species that are most commonly referred to in the context of air quality assessments. Both VOC's and SVOC's contain hydrogen and carbon but are differentiated according to the respective vapour pressure (volatility) of the individual species. VOC's exist in the gaseous state in the ambient atmosphere and have a vapour pressure of 0.01 kPa or greater at 25C, while SVOC's have a vapour pressure between 1.3E-9 and 0.01 kPa at 25C [10, 11]. SVOC's exist as both solid and gaseous fractions.

An important source of hydrocarbon emissions to the atmosphere is the transportation sector because hydrocarbons are emitted from engine exhaust as well as evaporative losses of fuel. Once emitted, these compounds can react with nitrogen oxides in the presence of sunlight to form ozone. The direct effects of hydrocarbons on health or on the environment depend on the individual compound. There are no Ontario criteria for total hydrocarbons; however, criteria and standards exist for specific organic compounds. Tables 7 and 8 present the results of data collected from select MOE stations in the Region for a number of VOC's and PAH's, respectively, for the years 1992 to 1995.

Data contained within Table 7 show that although the 24-hour criteria have been established for various VOC's, average values and 1995 maximums are consistently well below the AAQC's. The columns containing the number of detects for each compound at the monitoring stations indicate that several VOC's (such as hexane, benzene and toluene) were consistently detected, but at low levels.

Table 8 shows that benzo(a)pyrene is the only PAH with an ambient air quality criteria. Results show that the 24-hour criteria of 1.1 ng/m^3 for this compound was exceeded eight times during 1995 at MOE Station #29113. Most of the remaining PAH's listed were consistently detected during sampling periods but at low levels.

Table 7: Statistical Summary of Ambient Volatile Organic Compound Measurements for 1995 (ng/m^3) at 3 MOE Stations

		29000 - Elgin/Kelly						29113 - Gertrude/Depew						29114 - Vickers/East 18th					
	24 Hour AAQC	No Of Detects	Average 1995	Average 1994	Average 1993	Average 1992	Max 1995	No. Of Detects	Average 1995	Average 1994	Average 1993	Average 1992	Max 1995	No Of Detects	Average 1995	Average 1994	Average 1993	Average 1992	Max 1995
VINYL CHLORIDE	1	0						0						0					
1,3-BUTANE		11	0.1	0.1	0.1		0.3	5		0.1	0.1	0.1	0.6	7	0.1	0.1	0.1		0.3
ISOPRENE		23	0.2	0.2	0.2	0.2	0.4	24	0.5	0.2	0.1	0.2	8.5	19	0.1	0.1	0.1	0.2	0.4
1,1-DICHLORETHANE	35	26	0.1	0.1	0.2	1.0	0.3	11	0.7	0.1	0.2	1.2	14.8	13	0.1	0.1	0.1	1.4	0.3
DICHLOROMETHANE	1,65	26	1.8	2.7	0.9	1.9	3.7	25	15.1	1.5	0.5	1.4	353.0	24	2.1	4.0	2.1	1.4	9.8
1,1-DICHLOROETHANE		0						2				0.1	0.4	0					
HEXANE	12,00	26	4.9	3.9	4.3	10.6	30.2	26	11.4	2.8	2.2	4.4	242.0	24	1.3	1.2	1.2	2.4	3.9
TRICHLOROMETHANE	500	16	0.1	0.1	0.1	0.4	0.1	18	0.1	0.1	0.9	0.3	0.6	16	0.1	0.1	0.1	1.2	0.1
1,2-DICHLOROETHANE	400	0				0.1		2				0.1	0.3	0					
CYCLOHEXANE	100,000	25	0.2	0.2	0.3	0.5	0.7	25	1.9	0.3	0.2	0.5	45.9	23	0.1	0.1	0.1	0.6	0.4
CARBON TETRACHLORIDE	600	26	0.4	0.4	0.4	3.4	0.7	25	0.6	0.4	0.4	1.6	2.3	24	0.5	0.4	0.4	0.3	0.7
BENZENE		26	2.9	2.2	3.0	4.8	14.5	26	8.1	6.3	3.7	7.3	65.7	24	1.9	1.9	1.9	3.9	8.4
TRICHLOROETHYLENE	28,000	23	0.1	0.1		0.2	0.3	22	0.4	0.2	0.1	0.2	5.7	19	0.1	0.1		0.3	0.3
1,1,1-TRICHLOROETHANE	115,000	26	1.3	1.6	3.1	1.2	2.9	25	2.8	1.4	2.2	4.8	33.1	24	0.7	0.6	0.8	1.3	3.0
1,2-DICHLOROPROPANE	2,400	0						1					0.2	0					
TOLUENE	2,000	26	4.8	5.1	5.9	8.4	11.0	26	8.7	7.4	6.6	7.1	88.6	24	3.2	3.0	3.1	3.0	8.4
1,1,2-TRICHLOROETHANE		0						0				0.4		0					
1,2-DIBROMETHANE		0						0				0.5		0					
TETRACHLOROETHYLENE	4,000	26	0.6	0.9	1.7	3.7	1.4	25	2.2	0.5	0.4	0.8	46.7	23	0.4	0.3	0.4	0.4	3.4
CHLOROBENZENE		0						1	0.1				0.2	0				0.4	
ETHYLBENZENE	4,000	26	0.8	0.9	0.9	1.6	2.5	26	1.1	1.4	1.2	1.6	5.6	24	0.5	0.6	0.6	0.7	2.1
M-XYLENE	2,300	26	2.8	2.9	3.1	5.0	9.1	26	3.6	4.9	4.4	3.6	15.0	24	1.8	2.0	2.2	1.5	7.4
STYRENE	400	22	0.1	0.1	0.1	0.5	0.5	23	0.3	0.3	0.2	0.4	1.9	9	0.1	0.1		0.2	0.4
O-XYLENE	2,300	26	0.8	1.0	1.0	1.6	2.1	26	1.1	1.7	1.4	1.7	5.3	24	0.5	0.7	0.7	0.8	1.7
1,1,2,2-TETRACHLOROETHANE		0				0.4		1				0.2	0.1	1					0.1
a-PINENE		16	0.1	0.5			0.5	19	0.2	0.1			0.8	16	0.4	0.2			1.4
1,3,5-TRIMETHYLBENZENE		26	0.3	0.5	0.5	0.7	0.6	25	0.4	0.7	0.7	1.2	1.3	21	0.2	0.3	0.4	0.9	0.6
1,2,4-TRIMETHYLBENZENE	1,000	26	0.9	1.7	1.4	1.6	1.5	25	1.1	2.1	1.8	2.9	3.7	24	0.5	1.0	1.2	0.9	1.6
1,3-DICHLOROBENZENE		0						0				0.4		0					
1,4-DICHLOROBENZENE		7	0.1	0.2	0.3	0.2	0.2	8	0.1	0.2	0.2	0.5	0.5	4		0.1	0.1	0.1	0.2
1,2-DICHLOROBENZENE	30,500	0						1				0.2	0.1	0					
NAPTHALENE	22.5	24	0.8	1.6			3.5	25	2.2	3.1	2.0	1.0	10.0	19	0.9	1.2	1.4		6.4

Source Reference 3

Table 8: Statistical Summary of Ambient Polycyclic Aromatic Hydrocarbon Measurements for 1995 at 2 MOE Stations (ng/m³)

		29113 - Gertrude/Depew							29114 - Vickers/East 18th						
	24 Hour AAQC	No Of Detects	Average 1995	1994	1993	1992	Max 1995	No. Times Over Criteria	No Of Detects	Average 1995	1994	1993	1992	Max 1995	No Times Over Criteria
PAH TOTAL		27	146 0	330 6	219 6	515 5	474.2		28	77 1	107.5	98 4	133.9	284.0	
BIPHENYL		27	17 9	28 5	20 4	44	54 8		28	10 6	11.6	12.5	16.2	32 5	
ACENAPHTHYLENE		27	16 6	35 7	28 3	49 2	61.9		28	7 6	11 9	9	16 6	41 1	
ACENAPHTHENE		26	14.3	49 1	18	130	69 6		28	7 7	13 4	10 4	25 9	49 5	
FLUORENE		27	19 5	40 9	23.5	49.6	99.2		28	9 6	14 2	13 3	15 6	41.5	
PHENANTHRENE		23	29 3	83 9	52.7	129	154 0		25	16 9	28 2	27 2	26 3	48.2	
ANTHRACENE		26	1 6	15 9	7.9	13 1	7.1		25	0 7	1 8	1 8	3.4	3 4	
O-TERPHENYL		11	0 2	0 2	0.3	0 4	1 1		14	0 3				1 3	
1-METHYLPHENANTHRENE		27	2 9	3 5	2 8	5 9	11.0		28	1.3	1.2	1.2	1 9	4.8	
FLUORANTHENE		26	12 8	23 0	19.1	28 8	45 5		28	7 3	8.0	8.1	8 8	36 6	
PYRENE		27	9.6	16 5	15.1	19.8	28 8		28	4 7	5 5	6.5	6 1	25 6	
M-TERPHENYL		27	0 2	0 2	0 2		0 4		26	0 1	0 1	0 1		0 3	
P-TERPHENYL		0	0 1						0						
BENZO(A)FLUORENE		25	1 4	2 1	1 6	4 3	7 8		27	0 6	0 6	0 6	1 6	3 5	
BENZO(B)FLUORENE		24	1.6	2 0	1.3	3 1	9 5		20	0.7	0.6	0 4	1 0	4.3	
BENZO(A)ANTHRACENE		26	2 3	4 1	3 1	6	13.2		27	1 0	1 2	0.8	1.5	5 6	
CHRYSENE		27	3 5	5 7	4.6	6.1	16 6		27	1 7	2 0	1.5	1.9	9.9	
BENZO(B)FLUORANTHENE		27	4 4	4.0	3 3	10.5	22.4		27	2 2	1.5	1 1	2 6	11.2	
BENZO(K)FLUORANTHENE		25	1 4	2.4	2.4		6.5		24	0 8	0.9	0 8		3.7	
BENZO(E)PYRENE		23	1 2	3.5	2.9	3 4	4.7		22	0 5	1 3	1	1 1	2 0	
BENZO(A)PYRENE	1 1	24	0 9	3 0	2.2	3.1	3.0	8	25	0 4	0 8	0 5	0 8	1.9	2
PERYLENE		8	0 2	0 6	0 4	0 8	1 2		5		0.2	0 1		0 5	
INDENO(123CD)PYRENE		27	2.3	4 1	2.7	3.9	10.2		28	1.1	1.6	0.8	1 3	5 1	
DIBENZO(A,H)ANTHRACENE		22	0 5				2.9		23	0 2				1.2	
BENZO(GHI)PERYLENE		26	2.1	2 5	1 9	3 7	8 8		26	1 0	0 9	0 7	1 2	5 2	

Notes: 24-hour AAQC for B(a)P is 1.1 ng/m³
* reported together with benzo(b)fluoranthene
PAH Total not comparable to MOE totals

Source: Reference 3.

The following table summarizes the maximum 1-hour and 24-hour measurements from the Region's ambient air quality station at King Street and Mount Albion Road. Although only taken over the period December 19, 1997 to February 28, 1998, they are reflective of MOE readings taken at comparable urban sites in the Region.

Table 9: Summary of Ambient Air Quality Results for Primary Pollutants for the Period, December 19, 1997 to February 28, 1998. Units are in ppm except for PM10 which is in $\mu g/m^3$.

Contaminant	Maximum 1-hour Reading	1-Hour Ontario AAQC	Maximum 24-hour Reading	24-Hour Ontario AAQC
CO	6.7	31	2.5	N/A
NO	0.34	N/A	0.15	N/A
NO_2	0.07	0.21	0.04	0.11
NO_x	0.41	N/A	0.19	N/A
PM10	186	N/A	**53(1)**	50

Notes: N/A - Not applicable - no objective has been specified.
Any bolded values indicate levels in excess of the corresponding objective.
Any bracketed values indicate the number of measured readings above the objective.

3.2 Dispersion Climatology

The dispersion of pollutants emitted to the ambient air environment is directly dependent on atmospheric conditions. Wind direction, wind speed, temperature, time of day and atmospheric stability all play important roles in pollutant dispersion. To understand the normal atmospheric conditions within the Hamilton area, the dispersion climatology of the area must be defined. Historical data, collected at the Hamilton Airport and the MOE's Woodward Ave Station were considered and reviewed. Readings from the Woodward Avenue Station are more reflective of conditions near the bottom of the escarpment. These include onshore and offshore wind conditions caused by lake effects.

Five years of hourly meteorological readings periods (1991 to 1995) were collected from the MOE's Woodward Ave Station. Multiple levels of sensors on this 90 m tower enabled the creation of joint frequency distribution tables of wind speed by wind direction and by stability class. (Appendix B). Stability classes were also summarized by time of day (Appendix C). As there was a high number of calm wind readings at the 10 m height on the tower, hourly wind speed readings from the 30 m height were selected and adjusted to the 10 m height and coupled with the coincident 10m wind direction reading.

3.2.1 Wind Direction

Wind direction data from the MOE's Woodward Avenue Station for the years 1991 to 1995 were used to derive the wind rose shown in Figure 1. The wind rose presents the direction from which the wind originates. From the figure, it is evident that winds frequently originate from the south-southwest through west and north through east directions. The most frequent direction is south-southwest, and occurs about 13 percent of the time.

3.2.2 Wind Speed

The wind rose in Figure 1 also displays average wind speed (in meters per second) as a function of wind direction. It can be seen that average wind speeds by direction range from about 1.2 to 3.7 m/s. Calms occur just over 2 percent of the time and the overall average wind speed for the five year period is about 2.5 m/s (9.2 km/h).

3.2.3 Atmospheric Stability

Atmospheric stability is a measure of the turbulent mixing capacity of the atmosphere and is estimated from wind speed, temperature and solar radiation. Atmospheric stability is generally classified using the Pasquill-Gifford rating scheme from A to F, where A is unstable (greatest turbulent mixing) and F is the most stable (least turbulent mixing). Stability classes A or B are typically found in the mid-morning and afternoon periods when incoming solar radiation is greater. Stability classes E or F reflect light wind speeds and restricted mixing and are generally found in early evening (after 6 p.m.) through pre-sunrise periods. The method used to calculate hourly

atmospheric stability was the U.S. EPA's SRDT (solar radiation delta-temperature) stability classification method as provided in the MPRM meteorological data preprocessor [11, 12]. This method is based on continuous on-site solar radiation and 10 metre wind speed measurements during the day and vertical temperature gradients and 10 metre wind speed during the night.

It was found that stability classes A and B, the most unstable conditions, occurred at mid-day, and only about 10.4% of the total sample time. Stability Class D (neutral) was the most dominant condition and occurred about 53% of the time, and mostly in the late morning (9-11 am) and early evening (6-9 pm). Stable conditions (stability classes E and F) were found to occur about 21.7% of the time and as noted earlier, generally during night-time hours.

4. PREDICTED AIR QUALITY ENVIRONMENT

4.1 Determination of Vehicle Emission Factors

Environment Canada's MOBILE5C vehicular emissions model and the United States Environmental Protection Agency's PART5 particulate matter emission model were used to determine vehicular emission rates of CO and NO_x, and PM10, respectively [13, 14]. Vehicular emissions are expressed in terms of mass per distance traveled per vehicle. The results of the dispersion modelling are expressed in terms of units of concentration such as ppm (volume per volume) and $\mu g/m^3$(mass per volume).

The posted speeds (city street either 30 or 50 km/h ramps - 50 km/hr, expressway - 90 km/hr), the idle conditions, and the peak PM hourly traffic volumes for the year 2010 were used for this analysis. Year 2010 was selected for detailed analysis as it represents the period when the expressway will reach the vehicle design capacity. Vehicle registration distributions for Ontario are provided in the MOBILE5C user's manual [13]. The MOBILE5C model was run for all four seasons to determine which produced the highest emission factors. The results showed that higher emissions are more likely to occur during the winter season. Table 10 presents a summary of the inputs used with the MOBILE5C model. The operating year and mean traffic speeds in this table were based on the information provided by the Regional Municipality of Hamilton-Wentworth Roads Division. A summary for all of traffic measurements for PM rush-hour and AADT time periods are provided in Appendix D.

Table 10: MOBILE5C Model Input Parameters

Input Information	Value and Source
Ambient Temperature	-10.0 °C (derived from worst-case emission analysis)
Posted Vehicle Speeds	City streets 30 or 50 km/h, Ramps-50 km/h, Expressway-90 km/h
Province	Ontario
Operating Year	2010
Reid Vapour Pressure	15.5 psi
Vehicle Operating Mode	Default cold-start fraction
Vehicle Mix	Light Duty Gas Vehicles (LDGV): 58.6% Light Duty Gas Trucks (LDGT): 30.0% Heavy Duty Gas Vehicles (HDGV): 3.0% Light Duty Diesel Vehicles (LDDV): 0.2% Light Duty Diesel Trucks (LDDT): 0.4% Heavy Duty Diesel Vehicles (HDDV): 7.4% Motorcycles (MC): 0.5%

PART5 is a vehicle emission factor model that calculates emission factors from on-road automobiles, trucks, and motorcycles for particle sizes of 1 - 10 μm. The particle emission factors include exhaust particulate components, brakewear, tirewear and re-entrained road dust [14]. The PART5 inputs are presented in Table 11.

Table 11: PART5 Model Input Parameters

Input Information	Value and Source
Number of Precipitation Days	146
Posted Vehicle Speeds	City streets 30 or 50 km/h, Ramps-60 km/h, Expressway-90 km/h
Operating Year	2010
Fleet average vehicle weight (kg)	~2,800
Fleet average number of wheels	4

The emission rates derived from the two emission factor numerical models for the posted speeds provided by the Regional Municipality of Hamilton-Wentworth Roads Division are presented in Table 12.

Table 12: Predicted Vehicle Emission Rates

Pollutant	Vehicle Emission Rates (g/veh/mile)				Emission Factor Model Used
	30 km/h	60 km/h	90 km/h	Idle (g/s)	
CO	32.92	17.98	11.52	330.78	MOBILE5C
NO_x	2.05	2.07	2.69	7.83	MOBILE5C
PM10	13.41	13.41	13.41	0.1	PART5

4.2 Dispersion Model

The U.S. EPA's CAL3QHCR dispersion model was used to determine the worst-case CO and NO_x concentrations. The CAL3QHCR model includes a Gaussian line source dispersion model, CALINE-3, that predicts the air pollutant concentrations near highways and arterial streets due to emissions from motor vehicles. The contribution from free flow traffic conditions as well as idling conditions at intersections are included [15].

The number of roadway links that the CAL3QHCR can process is limited to 120. Whenever the road width, traffic volume, speed, or type of road (free flow or queue) changes, a new link must be defined. The expressway, ramp and intersection links are shown in Figures 3a to 3d. The model will calculate the contribution from all of the links to each individual receptor so that the impact of the entire roadway can be determined. This analysis occurs for each hour of meteorological data input and produces the maximum concentrations for each receptor.

The receptor locations were chosen to replicate those used in the 1989 study although as the roadway alignment has changed so too has the numbering scheme and individual locations. Many of the 137 receptor locations selected in the earlier RWDI study have been used again. One of the receptors (R85) was relocated as it was in the middle of the Mud Street interchange. Currently, there are 140 receptors. A large array of receptors were defined in the proposed multi-use trails and on-road bike routes between Queenston and Barton Roads. The receptor layout is presented in Figures 2a-2d.

The CAL3QHCR model processes one year of hourly meteorological data and calculates 1-hour and running 8-hour averaged CO; and 24-hour and annual block averaged PM10 concentrations. The model was modified to calculate the 1-hour and average NO_x concentrations when prompted. Background ambient levels were included in the predicted concentrations. The background ambient pollutant concentrations were taken from MOE Station 29000, at Elgin/Kelly in Hamilton and are presented in Table 13. Predicted 24-hour TSP concentrations were calculated by applying a factor of 2.38 times the PM10 results. This value was derived from ambient monitoring results (see Section 3.1.3).

Table 13: Background Ambient Air Quality Levels from MOE Station 29000.

Contaminant	Ambient Level	Averaging Period
PM10	27.5 $\mu g/m^3$	average annual value
CO	2.5 ppm	99th percentile annual value
NO_x	0.184 ppm	99th percentile annual value

Meteorological data was obtained for the years 1991-1995 from MOE Station 29026 located on Woodward Ave. in Hamilton. The year with the fewest calms and the highest frequency of E and F stability classes was selected for the model run since the EPA models do not handle wind speeds below 1 m/s. Analysis of the meteorological data for these criteria led to the use of 1993 in the dispersion runs. As mentioned earlier, the MPRM meteorological pre-processor was used to calculate hourly atmospheric stability and mixing heights [12].

Other required input parameters for the CAL3QHCR dispersion model include traffic volumes, traffic light cycle times, signal types and arrival rates. Information was provided by the Region but in the cases where no information was available, default model values were used. The surface roughness was estimated from aerial photos and road-way drawings and a roughness length (z_o) of 100 cm (urban) was used.

4.3 Study Scenario

The study scenario for the Red Hill Creek Expressway air quality impact assessment consisted of a number of factors that constitute a reasonable worst-case. The scenario included high background pollutant levels added to predicted concentrations derived from actual hourly meteorological measurements coupled with coincident vehicle movements. Specific details are summarised below:

- emission factors for CO and NO_x were derived from a worst-case emission analysis assuming January temperatures;

- the PM rush-hour traffic volumes were used for the predicted maximum 1-hour CO and NO_x concentrations;

- no allowance for gravitational settling or fallout;

- 1-year of hourly meteorological readings data (1993) were selected for use from the MOE Woodward Ave. Station in Hamilton; and

- background ambient levels: 99th percentile ambient NO_x and CO concentrations and the average annual PM10 concentration from the MOE monitoring station at Elgin and Kelly.

For the PM10 and TSP dispersion analysis, traffic volumes were varied by hour of day according to the following distribution in Table 14. This distribution was applied to Annual Average Daily Traffic (AADT's) supplied by the Region and was assumed to be appropriate for each day of the week [16].

Table 14: Percentage Traffic Distribution by Hour of Day [16]

Hour	Percent Distribution
0000	1.5%
0100	1.0%
0200	0.5%
0300	0.3%
0400	0.2%
0500	0.5%
0600	2.7%
0700	7.4%
0800	9.0%
0900	3.8%
1000	3.5%
1100	3.6%
1200	3.7%
1300	3.9%
1400	4.1%
1500	7.4%
1600	9.3%
1700	10.0%
1800	8.5%
1900	7.0%
2000	4.2%
2100	3.4%
2200	2.5%
2300	2.0%

5. ASSESSMENT OF IMPACTS

Ozone and SO_2 have not been included in the this study and will not be considered in the present study. SO_2 is emitted as a result of fuel combustion and is directly related to the sulfur content of the fuel being used. Sulfur is a very minor constituent of gasoline (about 0.05%) and is present in less significant amounts in diesel fuel. SO_2 emissions are commonly reduced by decreasing the amount of sulfur contained in the fuel. As emissions of SO_2 constitute a small fraction of relative to CO and NO_x and the 1-hour criteria is comparable to NO_2, SO_2 was not carried forward in the analysis. Ozone levels are associated with long range transport and are not typically related to local vehicular emissions. Ozone levels within the Hamilton area are influenced by emissions from all of southern Ontario, or even a greater area, and are also dependent on atmospheric conditions and complex photochemical reactions. To accurately assess ground level ozone levels, an entire air-shed study would be required. This was outside the scope of this project.

5.1 Air Quality Modelling Results

The results of the CAL3QHCR modelling runs have been plotted with the proposed RHCE roadway alignment and are located in the Figures section. The predicted 1-hour CO and NO_2 concentrations are provided for the four roadway sections in Figures 4a to 4d and 5a to 5d, respectively and summarized in Appendix E. The predicted 24-hour PM10 and TSP concentrations are provided for the four roadway sections in Figures 6 a to 6d and 7a to 7d, respectively,

The following sections discuss the results for the dispersion model runs.

5.1.1 Carbon Monoxide

The maximum predicted 1- and 8-hour CO concentrations were summarized at all of the modelled receptors in Table 1 of Appendix E. The maximum 1-hour CO concentrations are illustrated in Figures 4a-4d. The CO concentrations presented include a background level of 2.5 ppm. All of the predicted CO concentrations are well below the MOE's ambient air quality criteria of 30 ppm for Ontario. The highest predicted CO concentration was 5.7 ppm (6,900 $\mu g/m^3$), which

occurred at Receptor 142, located on the edge of the creek on the west side of the expressway, approximately 600 m northeast of Queenston Road (Figure 3c) during winds from the northeast. The second highest concentration was 5.5 ppm, which occurred at Receptor 98, located on the playing fields near Glen Castle Drive.

With respect to the 8-hour predicted CO levels, the highest (5 ppm) and second highest (4.3 ppm) predicted concentrations were found to occur at Receptors 99 and 120, respectively. Receptor 99 is located on the playing fields and Receptor 120 is located on the west side of the expressway approximately 600m north of Queenston Rd. None of the predicted 8-hour levels were found to exceed the applicable AAQC.

5.1.2 Oxides of Nitrogen

The CAL3QHCR model was also run to simulate NO_x emissions from the vehicles on the roadway. The maximum predicted 1-hour NO_x concentrations were summarized at each modelled receptor in Table 2 of Appendix E. The NO_x concentrations presented include a background level of 0.19 ppm. The maximum predicted 1-hour NO_x concentration was 0.69 ppm, which occurred at Receptors 98 and 142.

Short-term NO_2 levels were calculated for the maximum predicted NO_x levels using the Ozone Limiting Method which is discussed in the next section.

5.1.2.1 The Ozone Limiting Method

The Ozone Limiting Method (OLM) is a technique used to estimate the maximum short-term NO_2 concentrations resulting from emissions of NO_x, in order to assess compliance with the ambient air quality criteria for NO_2. Predicted concentrations of NO_x (calculated by CAL3QCHR) were compared to the measured ambient concentrations of ozone (O_3). A factor of 0.10 is assumed for the thermal conversion of NO_x to NO_2 for combustion sources. If the remaining concentration of NO_x is less than the concentration of ozone, then it is assumed that 100% of the NO_x is converted to NO_2 according to the following equation:

$$NO_2 = NO_x \; for \; 0.9NO_x \leq O_3$$

If, however the concentration of NO_x is greater than that of O_3, then O_3 is the limiting factor and the following relationship applies:

$$NO_2 = 0.1NO_x + O_3 \; for \; 0.9NO_x > O_3$$

The OLM has gained regulatory acceptance for the purpose of conducting environmental assessments in Ontario [17].

The OLM analysis was conducted using the 99th percentile concentration of ozone (83 ppb) from the ambient air quality monitoring station at Elgin and Kelly (MOE Station #29000) in Hamilton.

5.1.2.2 Nitrogen Dioxide

The predicted NO_2 concentrations, calculated using the OLM are summarized in Table 3 of Appendix E and are depicted in Figures 5a-5d. All of the predicted NO_2 concentrations are well below Ontario's ambient air quality criteria of 0.21 ppm. The highest NO_2 concentration was 0.15 ppm, which was predicted to occur at two receptor locations; Receptor 48 located on the playing fields near Glen Castle Drive, during winds from the southwest, and Receptor 142, located on the edge of the creek on the west side of the expressway, approximately 600 m northeast of Queenston Road, during winds from the northeast.

Predicted 24-hour NO_2 concentrations were also found to be below the AAQC of 0.10 ppm.

5.1.3 Particulate Matter as PM10

The maximum predicted 24-hour PM10 concentrations are summarized at each modelled receptor in Table 4 of Appendix E and are depicted in Figures 6a-6d. The concentrations presented include a background level of 27.5 $\mu g/m^3$. Maximum 24-hour TSP concentrations are predicted to exceed the provincial criterion at most of the receptors. The highest predicted PM10 concentration was 249 $\mu g/m^3$, which occurred at Receptor 142, located on the edge of the creek on the west side of the expressway, approximately 600 m northeast of Queenston Road.

The second highest predicted PM10 concentration was 208 $\mu g/m^3$ which occurred at Receptor 120.

5.1.4 Particulate Matter as Total Suspended Particulate

Concentrations of TSP were not modelled directly but were estimated by applying a factor of 2.38 to the modelling results for PM10 (see Section 3.1.3). The maximum predicted 24-hour TSP concentrations at each of the receptor locations are presented in Table 5 of Appendix E and Figures 7a-7d. The maximum 24-hour TSP concentrations are predicted to exceed the provincial criteria at most of the receptor locations. The maximum predicted 24-hour TSP concentrations was 598 $\mu g/m^3$ located at Receptor 142. Although located at a different receptor, this result agrees closely to that found (599 $\mu g/m^3$ at Receptor 129) in the 1989 RWDI study [1].

5.2 Discussion

Since the maximum concentrations of CO and NO_2 are below their applicable ambient air quality criteria, the discussion of results will be limited to particulate matter (PM10 and TSP).

5.2.1 Inhalable and Total Suspended Particulate Matter

Predicted concentrations of particulate matter are directly related to the silt loading value applied in the PART5 emission factor model. It is typically recommended that site specific silt loading values be applied to estimate emissions [18]. Unfortunately, there are no published data on paved road silt loadings in the Hamilton-Wentworth area. Guidance on an appropriate silt loading value was solicited from the MOE and the representative referred RWDI to the U.S. EPA [19]. Accordingly, a conservative default value of 0.5 g/m^2 for expressways, that is recommended by the U.S. EPA, was applied .

Although the PM10 concentrations were predicted to exceed the interim air quality criteria at some of the receptors, the likelihood of the peak traffic volumes coinciding with stable atmospheric conditions is small, as previously discussed. Based on the results of the predictive assessment, the 24-hour TSP and PM10 criteria will be exceeded at least 13% of the time at the receptors used.

Section 6.0 discusses various mitigation strategies that can be applied to reduce the impact from elevated particulate levels.

5.3 Comparison of Predicted Results to Ambient Roadway Measurements

As there are a number of assumptions and conservatisms in the air quality analysis, comparison of the predicted results to ambient measurements is always informative in order to assess the level of conservatism. In other words, numerical models are always designed to intentionally over-estimate impacts. A similar outcome was found during the EA process for the proposed widening of Highway 404 in North York. A very large scale ambient air quality monitoring program was carried out by RWDI on behalf of the Ontario Ministry of Transportation and the MOE [20]. An intensive measurement program was completed over the Spring and Summer periods (120 days). Both TSP and PM10 were included in the program along with CO and oxides of nitrogen and other airborne contaminants. Upwind and downwind stations (about 30m

and 50m from the roadway) and a mobile monitoring station were used. Some of the highlights of the survey are summarised in Tables 15 and 16 below.

Table 15: Summary of Continuous 1-hour Measurement Results from Highway 404 Ambient Survey

Monitoring Site	Level	CO (ppm)	NO (ppm)	NO_2 (ppm)	NO_x (ppm)	THC (ppm)	TSP* (μg/m³)	PM10* (μg/m³)
West of 404	Avg.[1]	0.39	0.026	0.022	0.047	2.06	46.0	28.6
	Max.[2]	3.4	0.33	0.098	0.385	12.3	114.6	73.1
East of 404	Avg.	0.64	0.050	0.025	0.075	2.20	52.6	29.7
	Max.	3.0	0.383	0.143	0.398	5.8	137.8	78.3
Mobile	Avg.	0.43	0.010	0.020	0.030	2.55	N/A	22.9[3]
	Max.	4.3	0.249	0.079	0.301	10.7	N/A	65.8

Notes: [1] Arithmetic average (mean value) of all measurements over the entire monitoring period of the study.
[2] Maximum hourly value of the entire monitoring period for the gases.
* 24-hour readings are taken from high volume samplers except for mobile PM10 readings which are continuous (TEOM monitor)

Table 16: Comparison of Maximum Readings from Highway 404 Ambient Survey and Predicted Values for RHCE North-South Section

Study	1-hour CO (ppm)	1-hour NO_2 (ppm)	1-hour NO_x (ppm)	24-hour TSP (μg/m³)	24-hour PM10 (μg/m³)
Measured Highway 404	4.3	0.14	0.40	137.8	78.3
Predicted RHCE North-South Section	5.7	0.15	0.70	598	249

The PM rush-hour traffic movements on the Highway 404 totalled about 8,400 during the ambient survey. Relative to the PM rush-hour on the RHCE at its busiest location (6400 movements), about 24% more vehicles use the Highway 404. This is evidence of the conservative nature of the modelled results.

Finally, with the exception of CO, the predicted maximum 1- and 24- hour concentrations are greater than the comparable ambient readings from the 5-years of MOE records summarised in Tables 2 to 6b.

5.4 Focus on Potentially High Impact Zones

One of the greatest impacted areas in the playing fields near Glen Castle Drive (Figure 2b). There is a variance in the levels predicted for the playing field due to their distances from the centre-line of the modelled link. Even though they appear equidistant from the road (Figure 3b), Receptor 96 is actually further from the link centerline than Receptor 99, resulting in lower predicted concentrations.

It should be noted that the potential for high impact zones not only includes the locations defined as receptors but also areas that are equidistant on both sides of the roadway. Subtle curves in the roadway alignment coupled with light and variable winds can lead to locally high levels of particulate matter on occasion. Based on the results of the dispersion modelling, maximum PM10 and TSP levels were predicted to exceed the 24-hour AAQC at downwind distances ranging from about 100 to 200m from the travelled roadway of the RHCE.

Figure 8 (overleaf) presents a concentration profile for PM10 downwind of Receptor 98 (Glen Castle Drive playing fields). Using the 24 hours of meteorological readings from February 14, 1993 which produced the maximum 24-hour PM10 concentrations, CAL3QHCR was run to predict PM10 levels at an additional series of downwind receptors. Receptor 98 is about 50m from the RHCE. Additional receptors were defined in 20m increments up to 500m. The results indicate that predicted PM10 levels would reach the interim criterion of 50 $\mu g/m^3$ at a downwind distance of about 200m east of Receptor 98 or 250m east of the RHCE roadway.

CAL3QHC3 was also rerun to determine the frequency of exceedance for PM10 at Receptor 98. Based on the year 1993, PM10 levels were found to exceed the 24-hour interim criteria about 96% of the time at this receptor. Although not consistent with the wind frequency distribution, the wind needs to blow across the highway toward the receptors for only 1 - 2 hours each day in order to cause a level in excess of the interim criteria. This assumes that the silt loading content (0.5 g/m^2) of the roadway surface remains the same. In fact, it varies because of a number of factors including the hour of the day, the season, as a function of the number of vehicle movements and the weather.

Based on the predictive results, Figure 9 (overleaf) presents the number of days by class where 24-hour PM10 levels at Receptor 98 would exceed the interim criteria. The greatest number of exceedences are expected to be in the range of 65 - 80 $\mu g/m^3$ where 50 to 60 days are indicated.

5.5 Relationship between RHCE Results and Hamilton Air Quality Initiative Study

A two year long study of the air quality in Hamilton (Hamilton Air Quality Initiative - HAQI) was completed in late October 1997 [21]. The study considered a number of airborne contaminants and identified inhalable particulate matter (especially sulphates) as being the compounds of interest with to respect human health. In general, the air quality is improving in Hamilton; however, problems persist especially where odours and particulate matter are concerned. It was estimated that about 55% of the PM10 originates from long range transport outside the Region to the urban area (downtown). About 15% comes from local industry in the Region and the remaining 30% from urban sources. A number of recommendations pertaining to further emission reductions from industry and from private and commercial vehicles. Fugitive dust control programs including regular sweeping and cleaning of roads, applying water on roadways, cleaning stations to prevent dust from being tracked out, covering open trucks, planting tree screens and other vegetation and paving heavily used truck routes.

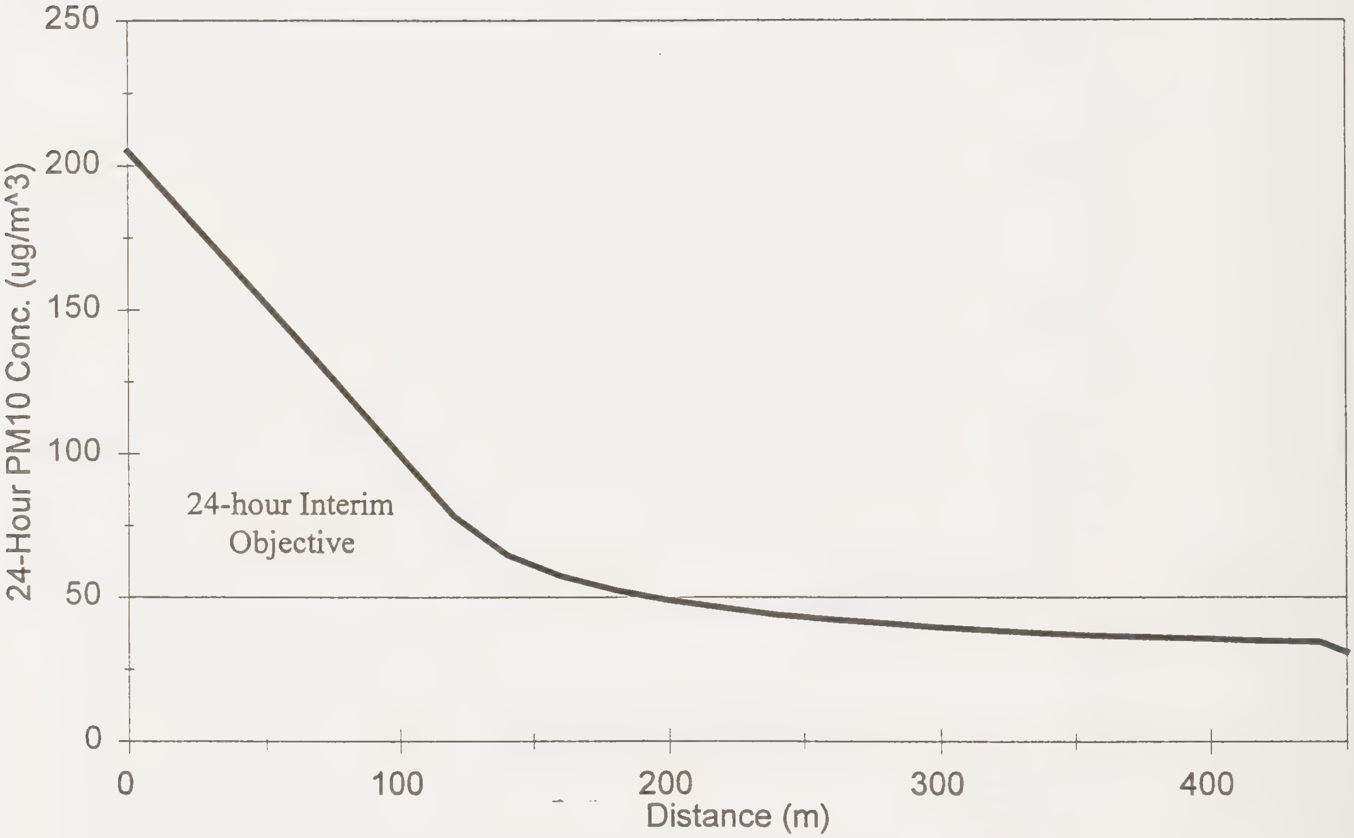

Figure 8: Maximum 24-hour PM10 Concentrations Downwind of Receptor 98 - January 14, 1993

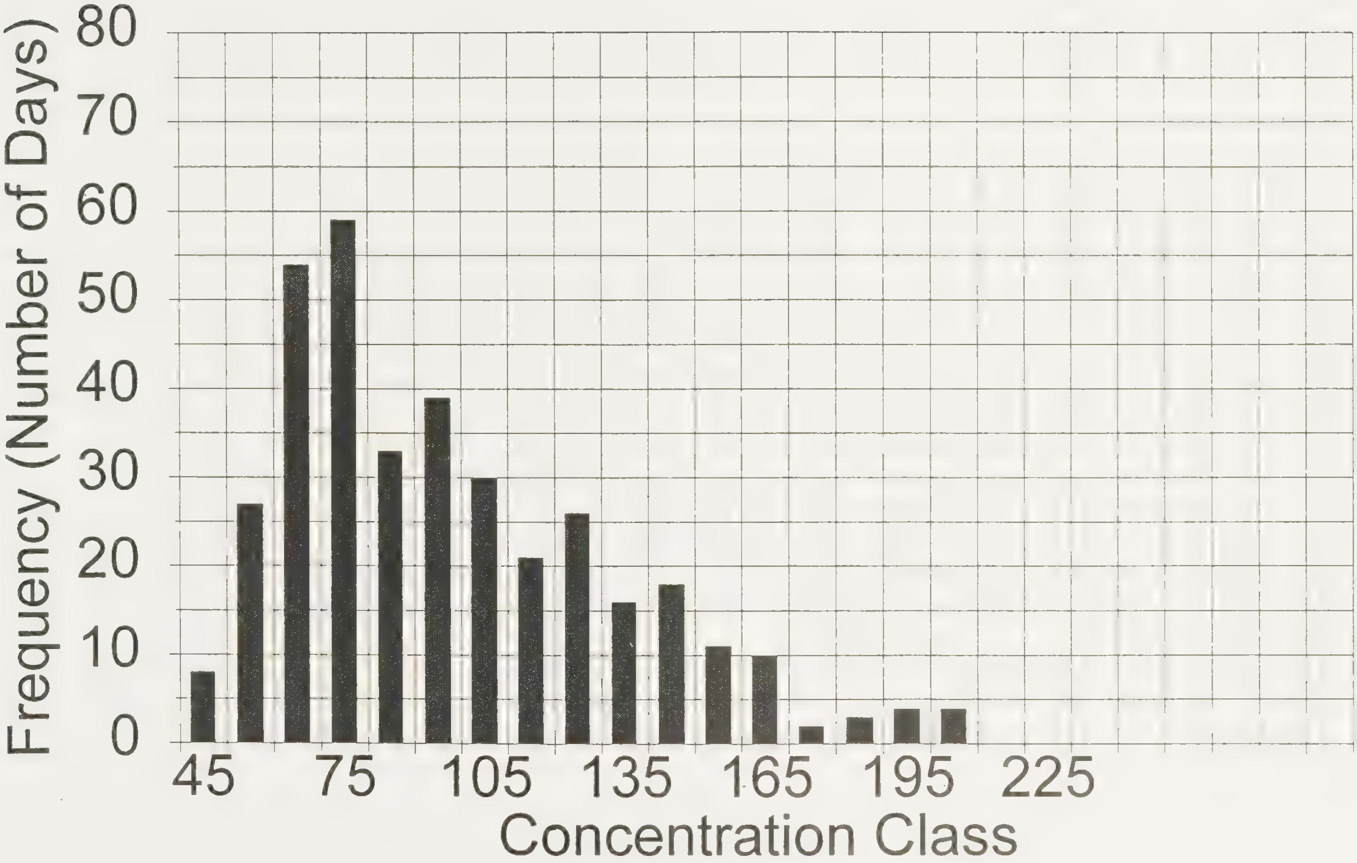

Figure 9: Frequency Distribution of PM10 Events in Excess of 24-hour Criteria at Receptor 98

5.6 Effects of Roadway Grade Changes on Contaminant Emission Rates

The models applied to predict the emission factors for the contaminants considered in this assessment do not address the impact due to increasing grade (going up hill). Studies have shown that grades of 3% or more can have a significant impact on emission rates of CO and HC. At about 85 km/h, hydrocarbon emissions in gasoline powered cars could increase by a factor of 3 and CO emissions by a factor of 11. For the case of CO emissions, any increase in the emission rate of CO due to an increase in load going up a hill is expected to be roughly balanced by the decrease in the emission rate experienced by vehicles going down the hill. For HC, however, coasting downhill results in an increase in HC emissions, but not as high as going uphill [22].

6. MITIGATION

As discussed in the results section, there is a need for mitigative measures to reduce the impacts of emissions of particulate matter from the roadway on the area surrounding the expressway. Mitigative measures fall into two different categories; removal and preventative techniques.

Examples of removal techniques include:

- natural processes such as rainfall and wind erosion; and
- implementing street cleaning methods (e.g., wet roadway sweeping and flushing [23].

Examples of preventative measures include the following:

- ensuring that there is vegetation along the expressway which limits soil erosion;
- reducing surface loadings by paving the shoulders of the road;
- reduction in the amount of sand and salt loading facilitated through improved plowing or utilization of a road surface texture to reduce ice adhesion; and
- washing of sand applied for de-icing, prior to application, removes a quantity of fine particulates that will become resuspend without reducing the effectiveness of the coarse particles which prevent skidding [23].

The natural processes are not reliable removal techniques, as they are sporadic. The effectiveness of the street cleaning methods mentioned are dependent upon the frequency, duration and timing [23]. Water flushing is reportedly more effective than sweeping; however, there is a potential to increase the carry on burden of particulate matter if the wet roadway road shoulders are not paved [24].

Given the sensitivity of the receptors located along the playing fields near Glen Castle Drive and the magnitude of predicted PM10 and TSP levels, it is recommended that wind screens be considered to reduce the impact from dust. Sound barriers are recommended in the traffic noise report for this location. Although barriers have been found in other studies not to be entirely effective for PM10, they do provide some relief in limiting horizontal dispersion of roadway emissions of larger dust particles. Trees will also be helpful in reducing the transport of suspended roadway dust outside of the valley. Consideration should be given to re-locating the Glen Castle playing fields. Finally, public sports events should be discouraged especially during rush-hour traffic periods.

Given the results of this study, we recommend that ambient air quality monitoring be considered at this location to establish existing background levels of air quality and second, to determine levels after the roadway has been completed. Details are provided below in the next section.

7. PROTOCOL FOR FUTURE AIR QUALITY MONITORING

In light of the potential for high ambient levels of particulate matter, which is attributable to the RHCE North-South Section, and especially the inhalable fraction, it is recommended that ambient air quality monitoring be carried out. Currently, a six month survey is in progress to establish background or existing air quality levels at the intersection of King Street and Mount Albion Road. A similar pre-construction survey should be carried out in the vicinity of the Glen Castle playing fields and perhaps the trail area on the west side of the RHCE between Barton Street and Queenston Road where the air quality assessment indicated that predicted air quality levels would be highest.

In addition to the pre-construction survey, at least six months and preferably twelve months of ambient measurements should be made after the North-South Section has been completed. Both the King Street/Mount Albion Road site and the Glen Castle Drive playing fields should be re-visited for this followup survey. Although two types of particulate matter (PM10 and TSP) have been implicated as being the most important parameters in this assessment, the other pollutants, namely CO, oxides of nitrogen, VOC's, and PAH's should also be included. These pollutants are related to vehicular emissions and provide a direct means of clarifying roadway impacts. The resident meteorological station should also be operated in conjunction with the ambient survey. The meteorological parameters help to document weather conditions during the air quality measurements and, among other things, help to establish the emission sources during only elevated episodes. The same sampling and calibration protocols that are currently in use should be extended into the future surveys.

Although establishing the appropriate alarm level(s) needs to be addressed in conjunction with air quality health professionals, consideration can be given to integrating a real-time display. The display can provide current as well as historical or trend results of ambient readings for PM10 and/or other criteria pollutants.

8. REFERENCES

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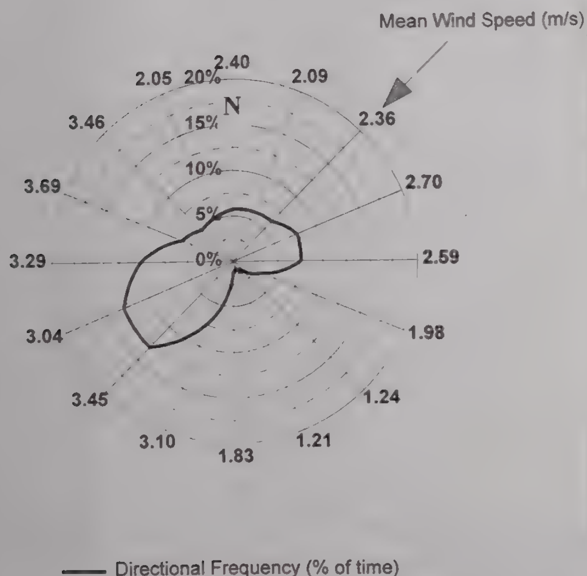
SELECTED HAMILTON MOE AIR QUALITY MONITORING STATIONS								
Label	Station	Location	CO	NO	TSP	PM10	VOC	PAH
A	29143	Keefer Ct			Y			
B	29135	Albright/Mt. Albion			Y			
C	29119	Morley/Parkdale			Y			
D	29113*	Gertrude/Depew			Y		Y	Y
E	29000**	Elgin/Kelly	Y	Y	Y	Y	Y	
F	29114	Vickers/E 18th		Y	Y	Y	Y	Y

* Station 29113 has ID number 29313 for hi-vol sampling of inhalable particulate.
** Station 29000 has ID number 29300 for hi-vol sampling of inhalable particulate.



Select MOE Ambient Air Quality Locations Near
Red Hill Creek Expressway North/South Corridor
Wind Rose is from MOE Woodward Ave. Station for the period, 1991-95.
Red Hill Creek Expressway EA - Hamilton, Ont.

True North

Job No. 97-207

Drawn by: DJM	Figure: 1
Scale:	1:50,000
Date Revised:	June 23,1998

RWDI

Roadway Links - Pritchard Road to Mount Albion Road

Red Hill Creek Expressway IADP - Hamilton, Ont.

True North	Drawn by: DJM	Figure: 2a
	Approx. Scale:	1:5000
Job No. 97-207	Date Revised:	May 15,1998

RWDI

Roadway Links - Mount Albion Road to King Street

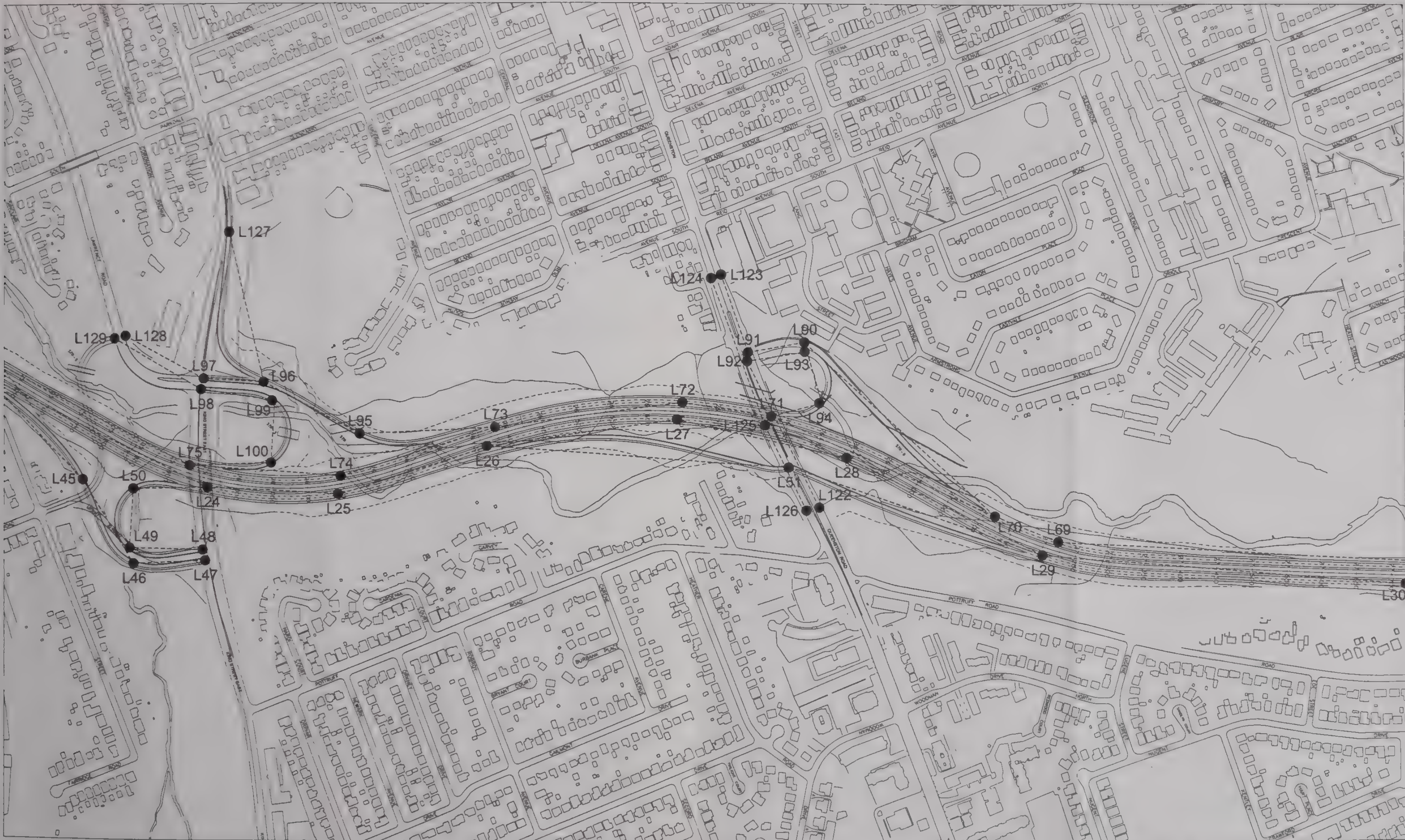
Red Hill Creek Expressway IADP - Hamilton, Ont.

True North

Job No. 97-207

Drawn by: DJM	Figure: 2b
Approx. Scale:	1:5000
Date Revised:	May 15,1998

RWDI



Roadway Links - King Street to Barton Street

Red Hill Creek Expressway IADP - Hamilton, Ont.

True North

Job No. 97-207

Drawn by: DJM	Figure: 2c	RWDI
Approx. Scale:	1:5000	
Date Revised:	May 15,1998	

Roadway Links - Barton Street to QEW

Red Hill Creek Expressway IADP - Hamilton, Ont.

True North

Job No. 97-207

Drawn by: DJM	Figure: 2d
Approx. Scale:	1:5000
Date Revised:	May 15,1998

RWDI

Location of Receptors - Pritchard Road to Mount Albion Road	True North	Drawn by: DJM	Figure: 3a	RWDI
		Approx Scale:	1:5000	
Red Hill Creek Expressway IADP - Hamilton, Ont.	Job No. 97-207	Date Revised:	May 15,1998	

Location of Receptors - Mount Albion Road to King Street

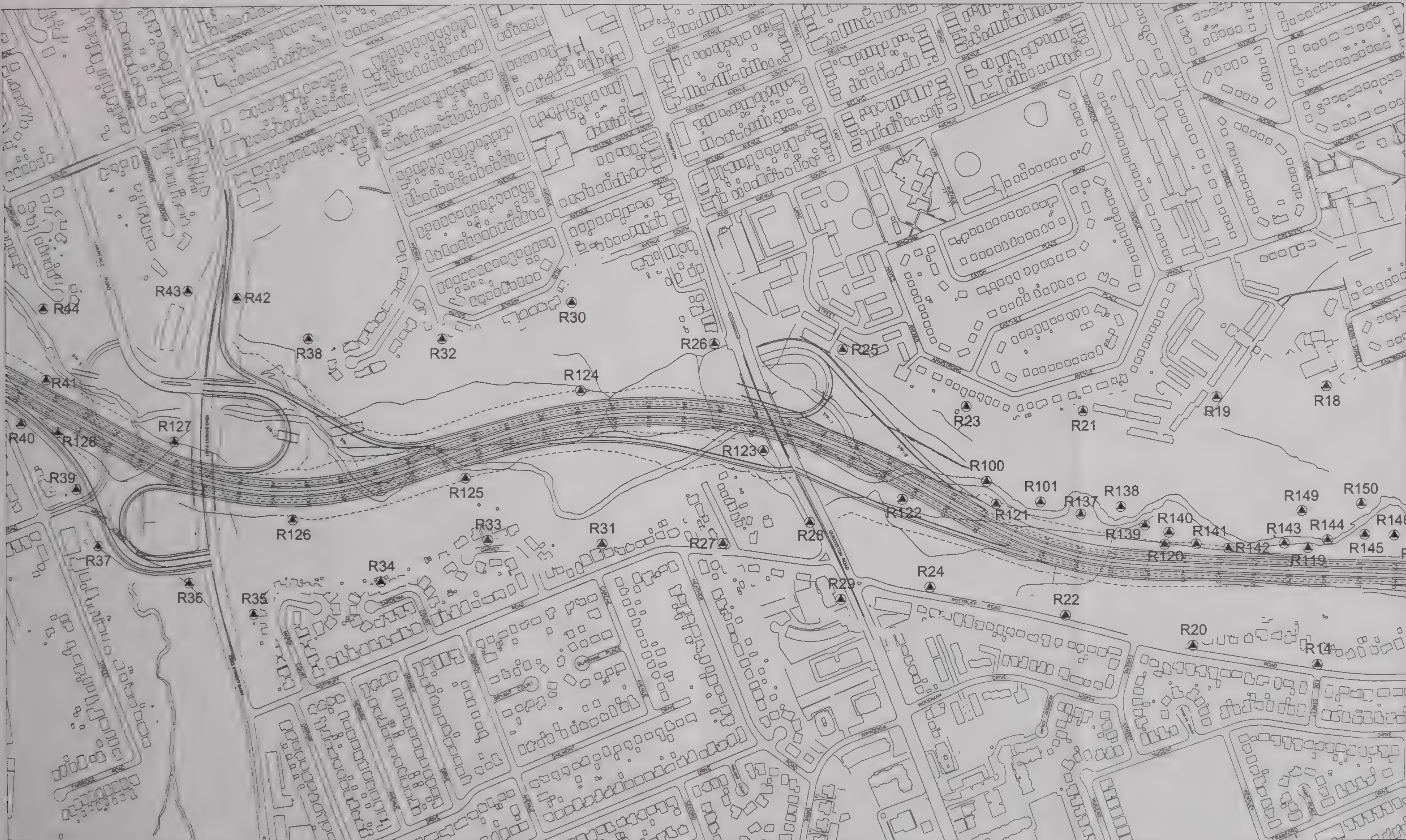
Red Hill Creek Expressway IADP - Hamilton, Ont.

True North

Job No. 97-207

Drawn by: DJM	Figure: 3b
Approx. Scale:	1:5000
Date Revised:	May 15,1998

RWDI



Location of Receptors - King Street to Barton Street

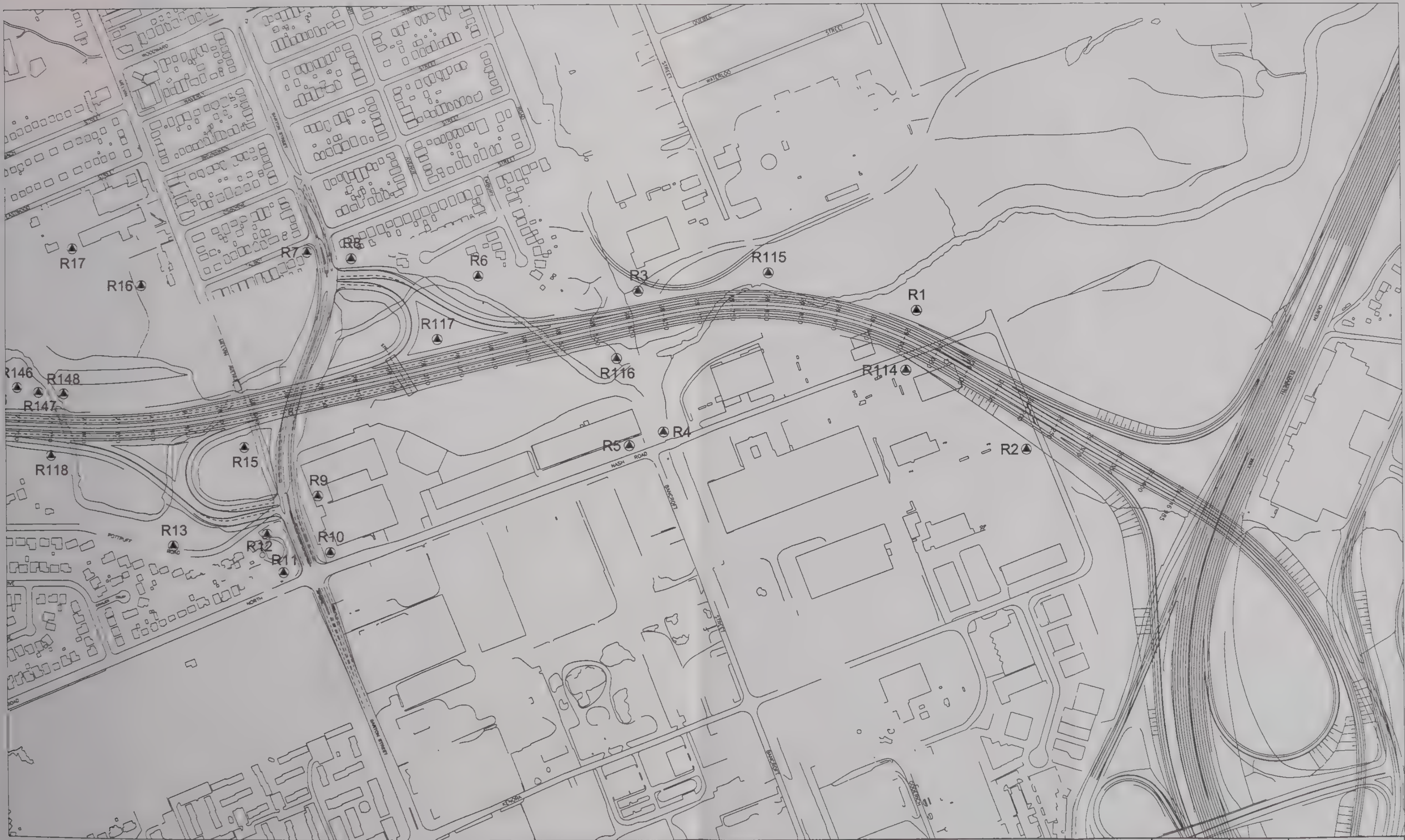
Red Hill Creek Expressway IADP - Hamilton, Ont.

True North

Job No. 97-207

Drawn by: DJM	Figure: 3c
Approx. Scale:	1:5000
Date Revised:	May 15,1998

RWDI



Location of Receptors - Barton Street to QEW

Red Hill Creek Expressway IADP - Hamilton, Ont.

True North

Job No. 97-207

Drawn by:	DJM	Figure:	3d
Approx. Scale:			1:5000
Date Revised:			May 15,1998

RWDI

Predicted Maximum 1-Hour CO Concentrations (in ppm) - Pritchard Road to Mount Albion Road
Wind Rose from MOE Woodward Ave. Station for the modelled year 1993

Red Hill Creek Expressway IADP - Hamilton, Ont.

True North

Job No. 97-207

Drawn by:	DJM	Figure:	4a
Approx. Scale:	1:5000		
Date Revised:	May 20,1998		

RWDI

Predicted Maximum 1-Hour CO Concentrations (in ppm) - Mount Albion Road to King Street
Wind Rose from MOE Woodward Ave. Station for the modelled year 1993

Red Hill Creek Expressway IADP - Hamilton, Ont.

True North	Drawn by: DJM	Figure: 4b
	Approx. Scale:	1:5000
Job No. 97-207	Date Revised:	May 20,1998

RWDI

Predicted Maximum 1-Hour CO Concentrations (in ppm) - King Street to Barton Street
Wind Rose from MOE Woodward Ave. Station for the modelled year 1993

Red Hill Creek Expressway IADP - Hamilton, Ont.

True North

Job No. 97-207

Drawn by: DJM	Figure: 4c
Approx. Scale:	1:5000
Date Revised:	May 20,1998

RWDI

Predicted Maximum 1-Hour CO Concentrations (in ppm) - Barton Street to QEW
Wind Rose from MOE Woodward Ave. Station for the modelled year 1993

Red Hill Creek Expressway IADP - Hamilton, Ont.

True North	Drawn by: DJM	Figure: 4d
	Approx. Scale:	1:5000
Job No. 97-207	Date Revised:	May 20,1998

RWDI

Predicted Maximum 1-Hour NO2 Concentrations (in ppm) - Pritchard Road to Mount Albion Road Wind Rose from MOE Woodward Ave. Station for the modelled year 1993	True North	Drawn by: DJM	Figure: 5a
		Approx. Scale: 1:5000	
Red Hill Creek Expressway IADP - Hamilton, Ont.	Job No. 97-207	Date Revised: May 20,1998	

RWDI

Predicted Maximum 1-Hour NO2 Concentrations (in ppm) - Mount Albion Road to King Street
Wind Rose from MOE Woodward Ave. Station for the modelled year 1993

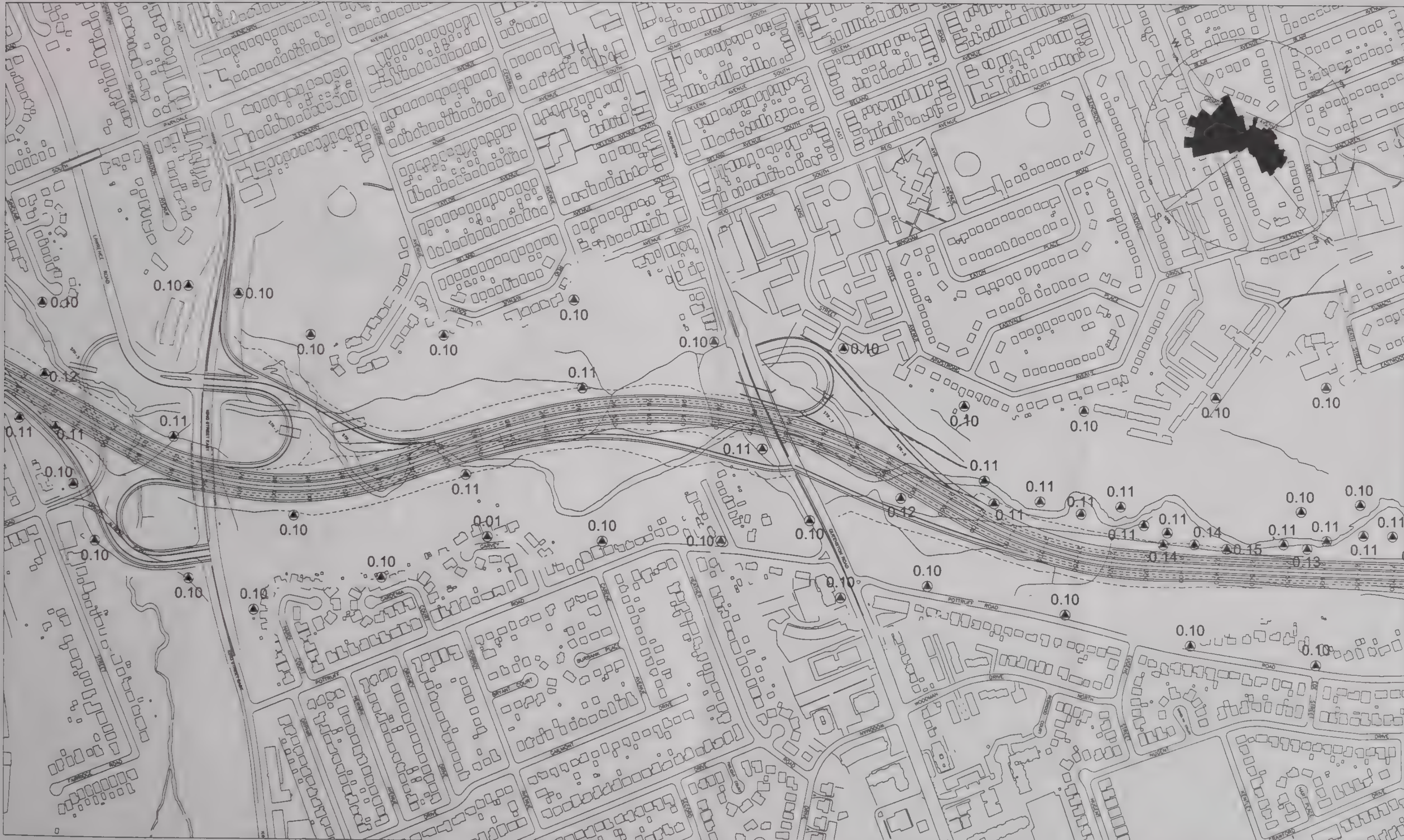
Red Hill Creek Expressway IADP - Hamilton, Ont.

True North

Job No. 97-207

Drawn by: DJM	Figure: 5b
Approx. Scale:	1:5000
Date Revised:	May 20,1998

RWDI



Predicted Maximum 1-Hour NO2 Concentrations (in ppm) - King Street to Barton Street Wind Rose from MOE Woodward Ave. Station for the modelled year 1993	True North	Drawn by: DJM	Figure: 5c
		Approx. Scale:	1:5000
Red Hill Creek Expressway IADP - Hamilton, Ont.	Job No. 97-207	Date Revised:	May 20,1998

RWDI

Predicted Maximum 1-Hour NO2 Concentrations (in ppm) - Barton Street to QEW
Wind Rose from MOE Woodward Ave. Station for the modelled year 1993

Red Hill Creek Expressway IADP - Hamilton, Ont.

True North

Job No. 97-207

Drawn by:	DJM	Figure:	5d
Approx. Scale:			1:5000
Date Revised:			May 20,1998

RWDI

Predicted Maximum 24-Hour PM10 Concentrations (in μg/m³) - Pritchard Road to Mount Albion Road True North
Wind Rose from MOE Woodward Ave. Station for the modelled year 1993

Red Hill Creek Expressway IADP - Hamilton, Ont.

Job No. 97-207

Drawn by: DJM	Figure: 6a
Approx. Scale:	1:5000
Date Revised:	May 20,1998

RWDI

Predicted Maximum 24-Hour PM10 Concentrations (in $\mu g/m^3$) - Mount Albion Road to King Street
Wind Rose from MOE Woodward Ave. Station for the modelled year 1993

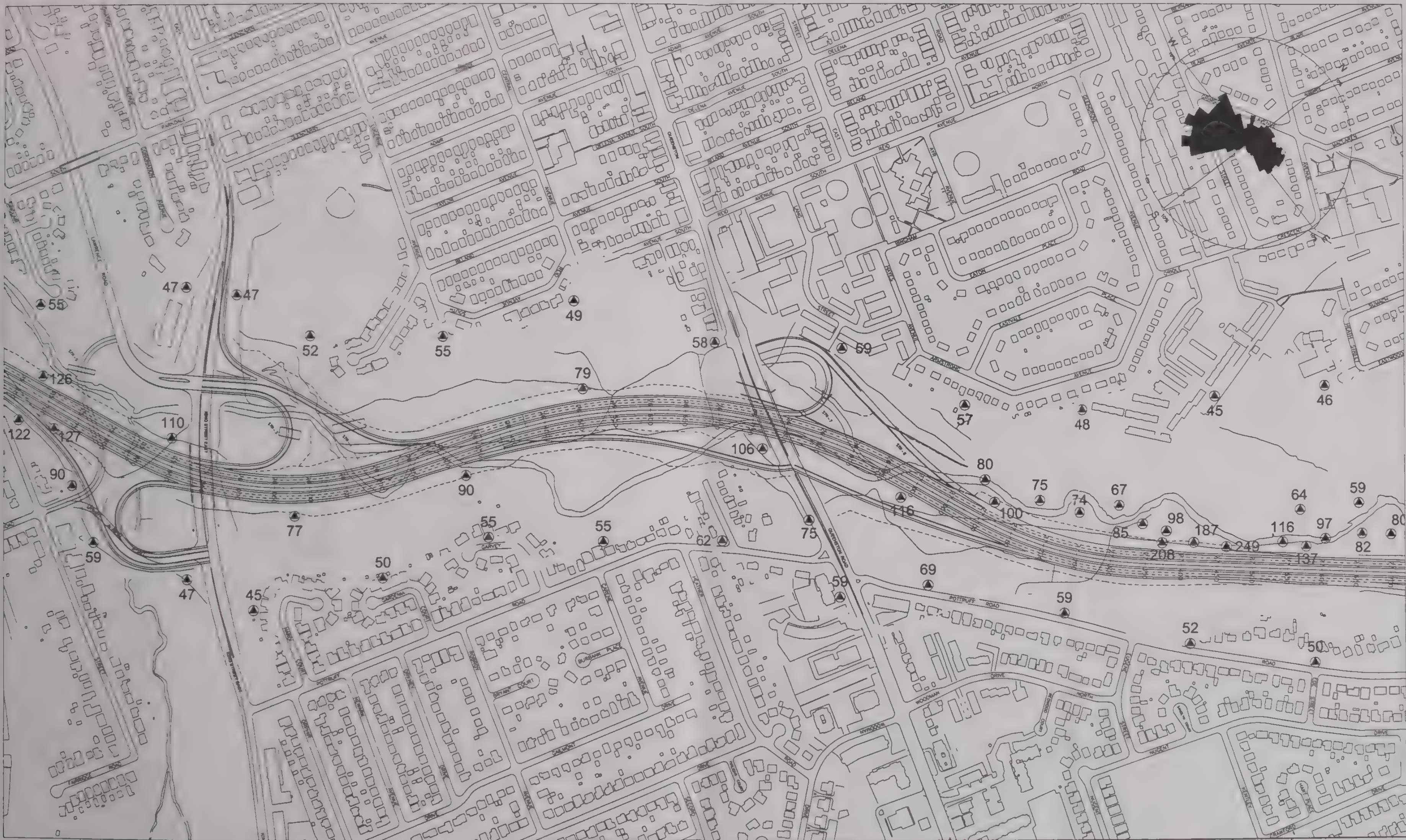
Red Hill Creek Expressway IADP - Hamilton, Ont.

True North

Job No. 97-207

Drawn by: DJM	Figure: 6b
Approx. Scale:	1:5000
Date Revised:	May 20,1998

RWDI



Predicted Maximum 24-Hour PM10 Concentrations (in $\mu g/m^3$) - King Street to Barton Street
Wind Rose from MOE Woodward Ave. Station for the modelled year 1993

Red Hill Creek Expressway IADP - Hamilton, Ont.

True North

Job No. 97-207

Drawn by:	DJM	Figure:	6c
Approx. Scale:			1:5000
Date Revised:			May 20,1998

RWDI

Predicted Maximum 24-Hour PM10 Concentrations (in $\mu g/m^3$) - Barton Street to QEW
Wind Rose from MOE Woodward Ave. Station for the modelled year 1993

Red Hill Creek Expressway IADP - Hamilton, Ont.

True North

Job No. 97-207

Drawn by: DJM	Figure: 6d
Approx. Scale:	1:5000
Date Revised:	May 20,1998

RWDI

Predicted Maximum 24-Hour TSP Concentrations (in $\mu g/m^3$) - Pritchard Road to Mount Albion Road
Wind Rose from MOE Woodward Ave. Station for the modelled year 1993

Red Hill Creek Expressway IADP - Hamilton, Ont.

True North

Job No. 97-207

Drawn by:	DJM	Figure:	7a
Approx. Scale:	1:5000		
Date Revised:	May 20,1998		

RWDI

Predicted Maximum 24-Hour TSP Concentrations (in $\mu g/m^3$) - Mount Albion Road to King Street
Wind Rose from MOE Woodward Ave. Station for the modelled year 1993

Red Hill Creek Expressway IADP - Hamilton, Ont.

True North

Job No. 97-207

Drawn by: DJM	Figure: 7b
Approx. Scale:	1:5000
Date Revised:	May 20,1998

RWDI

Predicted Maximum 24-Hour TSP Concentrations (in $\mu g/m^3$) - King Street to Barton Street
Wind Rose from MOE Woodward Ave. Station for the modelled year 1993

Red Hill Creek Expressway IADP - Hamilton, Ont.

Job No. 97-207

Drawn by: DJM	Figure: 7c
Approx. Scale:	1:5000
Date Revised:	May 20,1998

RWDI

Predicted Maximum 24-Hour TSP Concentrations (in $\mu g/m^3$) - Barton Street to QEW
Wind Rose from MOE Woodward Ave. Station for the modelled year 1993

Red Hill Creek Expressway IADP - Hamilton, Ont.

True North

Job No. 97-207

Drawn by: DJM	Figure: 7d
Approx. Scale:	1:5000
Date Revised:	May 20,1998

RWDI

APPENDIX A

APPENDIX A

Air Quality - Glossary of Terms

AAQC	-	Ambient Air Quality Criteria as defined by the Ontario Ministry of the Environment.
CO	-	carbon monoxide; a regulated air pollutant and product of incomplete combustion.
g/veh/mi	-	grams of emissions per vehicle per mile travelled.
MOE	-	Ontario Ministry of the Environment.
NO	-	nitric oxide; an air pollutant and constituent of NO_x generated by combustion.
NO_2	-	nitrogen dioxide; an air pollutant and regulated constituent of NO_x generated by chemical or photochemical reactions generally involving NO.
NO_x	-	total oxides of nitrogen; a generic air pollutant category that includes the sum of all NO and NO_2 concentrations.
O_3	-	ozone; a photochemical oxidant generally formed in the presence of sunlight, oxides of nitrogen and reactive hydrocarbons.
PAH's	-	polycyclic aromatic hydrocarbons; a class of airborne contaminants that exist with both solids and gaseous fractions. Individual species include fluoranthene and benzo(a)pyrene.
ppm, ppmv	-	parts per million by volume; unit of concentration; mixing ratio.
PM10		inhalable particulate matter; airborne particles of aerodynamic diameter less than 10 microns.
SO_2	-	sulphur dioxide; an air pollutant usually associated with the combustion of sulphur-laden fuel.
TSP	-	total suspended particulates; airborne particulate matter that is generally small (less than about 44 microns in diameter) enough so as not to be greatly affected by gravitational forces.
$\mu g/m^3$	-	micrograms per cubic metre; a unit of concentration.
U.S. EPA	-	the United States Environmental Protection Agency.
VOC's	-	volatile organic compounds; a class of airborne gaseous contaminants that includes individual chemical species such as benzene, xylenes, etc.

APPENDIX B

STABILITY CLASS A

DIR	CALM	>0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8	%FREQ
			Wind Speed (m/s) -->								
999	4	0	0	0	0	0	0	0	0	0	.0
10	0	1	0	1	0	0	0	0	0	0	.0
20	0	2	5	0	0	0	0	0	0	0	.0
30	0	5	9	0	0	0	0	0	0	0	.0
40	0	2	24	0	0	0	0	0	0	0	.1
50	0	9	47	5	0	0	0	0	0	0	.2
60	0	8	60	5	0	0	0	0	0	0	.2
70	0	6	84	7	0	0	0	0	0	0	.3
80	0	8	97	14	0	0	0	0	0	0	.3
90	0	8	72	9	0	0	0	0	0	0	.2
100	0	1	25	12	0	0	0	0	0	0	.1
110	0	3	7	0	0	0	0	0	0	0	.0
120	0	0	1	0	0	0	0	0	0	0	.0
130	0	1	1	0	0	0	0	0	0	0	.0
140	0	3	2	0	0	0	0	0	0	0	.0
150	0	0	2	0	0	0	0	0	0	0	.0
160	0	1	1	0	0	0	0	0	0	0	.0
170	0	0	8	0	0	0	0	0	0	0	.0
180	0	1	3	0	0	0	0	0	0	0	.0
190	0	1	1	0	0	0	0	0	0	0	.0
200	0	0	1	0	0	0	0	0	0	0	.0
210	0	2	8	1	0	0	0	0	0	0	.0
220	0	2	3	0	0	0	0	0	0	0	.0
230	0	0	3	0	0	0	0	0	0	0	.0
240	0	1	6	0	0	0	0	0	0	0	.0
250	0	2	4	1	0	0	0	0	0	0	.0
260	0	0	6	1	0	0	0	0	0	0	.0
270	0	1	2	1	0	0	0	0	0	0	.0
280	0	1	5	1	0	0	0	0	0	0	.0
290	0	0	4	2	0	0	0	0	0	0	.0
300	0	1	1	2	0	0	0	0	0	0	.0
310	0	0	2	1	0	0	0	0	0	0	.0
320	0	0	0	0	0	0	0	0	0	0	.0
330	0	4	3	0	0	0	0	0	0	0	.0
340	0	1	1	0	0	0	0	0	0	0	.0
350	0	1	3	0	0	0	0	0	0	0	.0
360	0	2	4	0	0	0	0	0	0	0	.0
SUM	4	78	505	63	0	0	0	0	0	0	
%ofTOT	.0	.2	1.4	.2	.0	.0	.0	.0	.0	.0	1.8

Total Observations in Stability Class A = 650

TOTAL OBSERVATIONS = 37944; TOTAL VALID DATA = 36431
(TOTAL # OF CALMS = 860; TOTAL MISSING DATA = 1513)

==

STABILITY CLASS B

DIR	CALM	>0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8	%FREQ
			Wind Speed (m/s) -->								
999	50	0	0	0	0	0	0	0	0	0	.1
10	0	14	35	6	5	2	0	0	0	0	.2
20	0	19	34	6	1	0	0	0	0	0	.2
30	0	28	70	5	4	1	0	0	0	0	.3
40	0	40	66	20	2	0	0	0	0	0	.4
50	0	61	125	32	18	1	0	0	0	0	.7
60	0	60	97	46	18	8	0	0	0	0	.6
70	0	48	123	51	27	6	0	0	0	0	.7
80	0	50	137	80	11	0	0	0	0	0	.8
90	0	26	126	129	24	3	0	0	0	0	.8
100	0	13	78	102	54	2	0	0	0	0	.7
110	0	4	20	3	1	0	0	0	0	0	.1
120	0	7	6	0	0	0	0	0	0	0	.0
130	0	4	3	1	0	0	0	0	0	0	.0
140	0	2	4	1	0	1	0	0	0	0	.0
150	0	5	2	0	0	0	0	0	0	0	.0
160	0	4	7	1	1	0	0	0	0	0	.0
170	0	9	10	4	0	0	0	0	0	0	.1
180	0	5	11	6	3	0	0	0	0	0	.1
190	0	9	6	4	1	0	1	0	0	0	.1
200	0	9	16	5	1	9	0	0	0	0	.1
210	0	7	26	11	26	10	0	0	0	0	.2
220	0	9	26	15	8	7	0	0	0	0	.2
230	0	10	21	14	24	12	0	0	0	0	.2
240	0	7	18	25	31	12	0	1	0	0	.3
250	0	10	22	8	17	5	0	0	0	0	.2
260	0	4	22	19	25	8	0	0	0	0	.2
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290	0	2	18	21	15	14	0	0	0	0	.2
300	0	3	10	13	9	6	0	0	0	0	.1
310	0	0	13	9	13	8	0	0	0	0	.1
320	0	3	13	7	9	6	0	0	0	0	.1
330	0	5	15	10	11	2	0	0	0	0	.1
340	0	10	15	8	3	2	0	0	0	0	.1
350	0	6	22	3	5	1	0	0	0	0	.1
360	0	6	17	0	3	1	0	0	0	0	.1
SUM	50	509	1292	720	412	154	1	1	0	0	
%ofTOT	.1	1.4	3.5	2.0	1.1	.4	.0	.0	.0	.0	8.6

Total Observations in Stability Class B = 3139

TOTAL OBSERVATIONS = 37944; TOTAL VALID DATA = 36431
(TOTAL # OF CALMS = 860; TOTAL MISSING DATA = 1513)

STABILITY CLASS C

DIR	CALM	>0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8	%FREQ
				Wind Speed (m/s) -->							
999	54	0	0	0	0	0	0	0	0	0	.1
10	0	16	20	34	31	9	2	0	0	0	.3
20	0	15	29	48	22	4	0	0	0	0	.3
30	0	26	24	47	23	5	0	0	0	0	.3
40	0	22	19	53	30	13	0	0	0	0	.4
50	0	20	17	64	42	24	6	0	0	0	.5
60	0	20	20	60	43	22	4	0	0	0	.5
70	0	16	23	71	34	12	7	0	0	0	.4
80	0	17	29	86	31	10	3	0	0	0	.5
90	0	16	16	151	29	7	2	0	0	0	.6
100	0	12	21	186	57	2	0	0	0	0	.8
110	0	4	12	38	17	3	0	0	0	0	.2
120	0	4	5	4	0	0	1	0	0	0	.0
130	0	4	3	2	1	0	0	0	0	0	.0
140	0	2	2	4	1	0	0	0	0	0	.0
150	0	1	1	3	1	0	0	0	0	0	.0
160	0	4	1	4	1	1	0	0	0	0	.0
170	0	3	1	8	4	2	0	0	0	0	.0
180	0	6	2	8	7	3	0	0	0	0	.1
190	0	1	3	13	11	4	2	1	0	0	.1
200	0	7	5	33	34	23	13	1	0	0	.3
210	0	7	14	50	82	72	18	0	0	0	.7
220	0	6	15	56	103	61	11	0	0	0	.7
230	0	11	16	64	70	67	10	0	0	1	.7
240	0	6	21	111	104	59	15	0	0	0	.9
250	0	9	17	99	103	61	9	0	0	0	.8
260	0	7	19	79	80	46	3	0	0	0	.6
270	0	6	22	95	102	73	11	0	0	0	.8
280	0	1	9	96	116	99	20	0	0	0	.9
290	0	5	6	61	73	70	21	0	0	0	.6
300	0	7	1	34	61	36	12	0	0	0	.4
310	0	2	3	27	40	48	8	0	0	0	.4
320	0	2	2	42	49	46	6	0	0	0	.4
330	0	5	10	46	38	17	4	0	0	0	.3
340	0	6	9	32	24	2	2	0	0	0	.2
350	0	3	10	31	23	14	1	0	0	0	.2
360	0	7	14	31	47	9	1	0	0	0	.3
SUM	54	306	441	1871	1534	924	192	2	0	1	
%ofTOT	.1	.8	1.2	5.1	4.2	2.5	.5	.0	.0	.0	14.6

Total Observations in Stability Class C = 5325

TOTAL OBSERVATIONS = 37944; TOTAL VALID DATA = 36431
(TOTAL # OF CALMS = 860; TOTAL MISSING DATA = 1513)

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STABILITY CLASS D

DIR	CALM	>0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8	%FREQ
				Wind Speed (m/s) -->							
999	152	0	0	0	0	0	0	0	0	0	.4
10	0	36	36	181	129	79	58	16	1	2	1.5
20	0	45	57	134	100	49	44	14	1	3	1.2
30	0	39	50	104	84	30	28	6	2	1	.9
40	0	56	50	111	80	39	27	26	9	4	1.1
50	0	35	53	99	78	46	63	43	13	9	1.2
60	0	36	47	88	80	57	82	78	48	28	1.5
70	0	35	54	95	72	47	56	71	41	61	1.5
80	0	28	42	101	76	52	57	33	26	37	1.2
90	0	35	69	92	86	47	48	32	33	60	1.4
100	0	22	54	100	55	24	27	19	18	14	.9
110	0	18	26	68	39	6	4	2	1	1	.5
120	0	18	17	63	17	1	2	0	0	0	.3
130	0	13	18	20	7	3	2	1	0	0	.2
140	0	10	12	12	3	0	0	1	0	0	.1
150	0	6	14	7	2	0	1	0	0	0	.1
160	0	8	12	7	1	0	2	0	1	0	.1
170	0	9	6	14	5	1	0	0	1	0	.1
180	0	8	12	28	9	5	3	2	2	0	.2
190	0	13	8	56	32	19	14	4	1	0	.4
200	0	15	19	109	115	65	78	36	5	9	1.2
210	0	18	39	200	254	177	221	138	49	36	3.1
220	0	15	50	323	351	197	247	139	73	45	4.0
230	0	22	54	308	303	166	202	118	50	27	3.4
240	0	26	88	422	312	235	232	108	19	18	4.0
250	0	20	58	409	343	204	167	62	20	11	3.6
260	0	21	38	355	290	143	123	54	11	10	2.9
270	0	5	25	311	274	137	118	63	27	11	2.7
280	0	10	22	222	454	198	183	64	27	12	3.3
290	0	8	11	125	130	106	164	66	15	6	1.7
300	0	4	6	73	93	43	63	38	12	1	.9
310	0	5	9	101	141	93	126	47	9	3	1.5
320	0	3	20	161	229	104	72	20	3	0	1.7
330	0	16	24	146	139	33	16	6	3	0	1.1
340	0	16	23	150	79	29	18	16	1	0	.9
350	0	20	30	157	119	56	33	5	2	3	1.2
360	0	36	39	145	161	84	45	16	1	1	1.4
SUM	152	730	1192	5097	4742	2575	2626	1344	525	413	
%ofTOT	.4	2.0	3.3	14.0	13.0	7.1	7.2	3.7	1.4	1.1	53.2

Total Observations in Stability Class D = 19396

TOTAL OBSERVATIONS = 37944; TOTAL VALID DATA = 36431
(TOTAL # OF CALMS = 860; TOTAL MISSING DATA = 1513)

STABILITY CLASS E

DIR	CALM	>0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8	%FREQ
				Wind Speed (m/s) -->							
999	198	0	0	0	0	0	0	0	0	0	.5
10	0	46	113	25	2	0	0	0	0	0	.5
20	0	59	126	28	1	0	0	0	0	0	.6
30	0	50	60	20	1	0	0	0	0	0	.4
40	0	46	59	13	0	0	0	0	0	0	.3
50	0	39	46	6	1	0	0	0	0	0	.3
60	0	39	42	8	0	0	0	0	0	0	.2
70	0	40	45	3	2	0	0	0	0	0	.2
80	0	14	24	5	1	0	0	0	0	0	.1
90	0	27	49	3	0	0	0	0	0	0	.2
100	0	25	61	12	0	0	0	0	0	0	.3
110	0	21	56	8	1	0	0	0	0	0	.2
120	0	35	43	15	0	0	0	0	0	0	.3
130	0	18	34	11	0	0	0	0	0	0	.2
140	0	28	31	7	0	0	0	0	0	0	.2
150	0	13	16	3	0	0	0	0	0	0	.1
160	0	10	15	4	1	0	0	0	0	0	.1
170	0	11	15	4	0	1	0	0	0	0	.1
180	0	16	20	6	0	0	0	0	0	0	.1
190	0	18	46	17	2	0	1	0	0	0	.2
200	0	22	51	31	6	0	1	0	1	0	.3
210	0	27	93	53	6	3	2	1	1	0	.5
220	0	32	106	88	10	3	1	0	0	0	.7
230	0	25	126	96	2	0	1	0	0	0	.7
240	0	30	145	99	0	0	0	0	0	0	.8
250	0	31	132	69	1	0	0	0	0	0	.6
260	0	28	109	57	1	0	0	0	0	0	.5
270	0	18	68	41	2	0	0	0	0	0	.4
280	0	11	46	25	3	0	0	0	0	0	.2
290	0	12	40	9	2	0	0	0	0	0	.2
300	0	11	31	2	0	0	0	0	0	0	.1
310	0	11	49	12	1	0	0	0	0	0	.2
320	0	24	48	16	0	0	0	0	0	0	.2
330	0	17	65	11	0	0	0	0	0	0	.3
340	0	28	104	11	0	0	0	0	0	0	.4
350	0	46	86	13	2	0	0	0	0	0	.4
360	0	55	88	18	0	1	0	0	0	0	.4
SUM	198	983	2288	849	48	8	6	1	2	0	
%ofTOT	.5	2.7	6.3	2.3	.1	.0	.0	.0	.0	.0	12.0

Total Observations in Stability Class E = 4383

TOTAL OBSERVATIONS = 37944; TOTAL VALID DATA = 36431
(TOTAL # OF CALMS = 860; TOTAL MISSING DATA = 1513)

STABILITY CLASS F

DIR	CALM	>0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8	%FREQ
			Wind Speed (m/s) -->								
999	402	0	0	0	0	0	0	0	0	0	1.1
10	0	69	61	0	0	0	0	0	0	0	.4
20	0	70	56	0	0	0	0	0	0	0	.3
30	0	67	51	0	0	0	0	0	0	0	.3
40	0	58	35	0	0	0	0	0	0	0	.3
50	0	68	19	0	0	0	0	0	0	0	.2
60	0	44	21	0	0	0	0	0	0	0	.2
70	0	44	24	0	0	0	0	0	0	0	.2
80	0	42	23	0	0	0	0	0	0	0	.2
90	0	45	21	0	0	0	0	0	0	0	.2
100	0	42	25	0	0	0	0	0	0	0	.2
110	0	31	34	0	0	0	0	0	0	0	.2
120	0	31	25	0	0	0	0	0	0	0	.2
130	0	32	23	0	0	0	0	0	0	0	.2
140	0	38	19	0	0	0	0	0	0	0	.2
150	0	28	14	0	0	0	0	0	0	0	.1
160	0	21	11	0	0	0	0	0	0	0	.1
170	0	19	18	0	0	0	0	0	0	0	.1
180	0	35	12	0	0	0	0	0	0	0	.1
190	0	34	34	0	0	0	0	0	0	0	.2
200	0	51	49	0	0	0	0	0	0	0	.3
210	0	51	69	0	1	0	0	0	0	0	.3
220	0	51	131	0	0	0	0	0	0	0	.5
230	0	63	146	0	0	0	0	0	0	0	.6
240	0	53	147	0	0	0	0	0	0	0	.5
250	0	61	131	0	0	0	0	0	0	0	.5
260	0	50	104	0	0	0	0	0	0	0	.4
270	0	36	70	0	0	0	0	0	0	0	.3
280	0	24	35	0	0	0	0	0	0	0	.2
290	0	15	10	0	0	0	0	0	0	0	.1
300	0	13	8	0	0	0	0	0	0	0	.1
310	0	24	6	0	0	0	0	0	0	0	.1
320	0	31	12	0	0	0	0	0	0	0	.1
330	0	32	25	0	0	0	0	0	0	0	.2
340	0	39	31	0	0	0	0	0	0	0	.2
350	0	52	44	0	0	0	0	0	0	0	.3
360	0	61	66	0	0	0	0	0	0	0	.3
SUM	402	1525	1610	0	1	0	0	0	0	0	
%ofTOT	1.1	4.2	4.4	.0	.0	.0	.0	.0	.0	.0	9.7

Total Observations in Stability Class F = 3538

TOTAL OBSERVATIONS = 37944; TOTAL VALID DATA = 36431
(TOTAL # OF CALMS = 860; TOTAL MISSING DATA = 1513)

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APPENDIX C

HOURLY SUMMARIES FOR Hamilton-Woodward Ave.

STABILITY CLASS A

		Wind Speed (m/s) -->									
HOUR	CALM	>0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8	%FREQ
1	0	0	0	0	0	0	0	0	0	0	.0
2	0	0	0	0	0	0	0	0	0	0	.0
3	0	0	0	0	0	0	0	0	0	0	.0
4	0	0	0	0	0	0	0	0	0	0	.0
5	0	0	0	0	0	0	0	0	0	0	.0
6	0	0	0	0	0	0	0	0	0	0	.0
7	0	0	0	0	0	0	0	0	0	0	.0
8	0	0	0	0	0	0	0	0	0	0	.0
9	0	1	3	0	0	0	0	0	0	0	.0
10	2	27	86	0	0	0	0	0	0	0	.3
11	0	19	121	0	0	0	0	0	0	0	.4
12	1	14	105	31	0	0	0	0	0	0	.4
13	1	9	82	31	0	0	0	0	0	0	.3
14	0	7	57	1	0	0	0	0	0	0	.2
15	0	1	50	0	0	0	0	0	0	0	.1
16	0	0	1	0	0	0	0	0	0	0	.0
17	0	0	0	0	0	0	0	0	0	0	.0
18	0	0	0	0	0	0	0	0	0	0	.0
19	0	0	0	0	0	0	0	0	0	0	.0
20	0	0	0	0	0	0	0	0	0	0	.0
21	0	0	0	0	0	0	0	0	0	0	.0
22	0	0	0	0	0	0	0	0	0	0	.0
23	0	0	0	0	0	0	0	0	0	0	.0
24	0	0	0	0	0	0	0	0	0	0	.0
SUM	4	78	505	63	0	0	0	0	0	0	
%ofTOT	.0	.2	1.4	.2	.0	.0	.0	.0	.0	.0	1.8

Total Observations in Stability Class A = 650

TOTAL OBSERVATIONS = 37944; TOTAL VALID DATA = 36431
(TOTAL # OF CALMS = 860; TOTAL MISSING DATA = 1513)

HOURLY SUMMARIES FOR Hamilton-Woodward Ave.

STABILITY CLASS B

		Wind Speed (m/s) -->									
HOUR	CALM	>0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8	%FREQ
1	0	0	0	0	0	0	0	0	0	0	.0
2	0	0	0	0	0	0	0	0	0	0	.0
3	0	0	0	0	0	0	0	0	0	0	.0
4	0	0	0	0	0	0	0	0	0	0	.0
5	0	0	0	0	0	0	0	0	0	0	.0
6	0	0	0	0	0	0	0	0	0	0	.0
7	2	5	1	0	0	0	0	0	0	0	.0
8	15	61	57	0	0	0	0	0	0	0	.4
9	8	132	128	0	1	0	0	0	0	0	.7
10	9	67	158	71	33	9	0	0	0	0	1.0
11	6	51	149	120	64	21	0	0	0	0	1.1
12	4	39	125	140	84	33	0	0	0	0	1.2
13	1	40	109	144	94	40	0	0	0	0	1.2
14	2	31	111	147	84	27	0	1	0	0	1.1
15	2	21	121	84	52	24	1	0	0	0	.8
16	1	22	149	14	0	0	0	0	0	0	.5
17	0	19	129	0	0	0	0	0	0	0	.4
18	0	21	55	0	0	0	0	0	0	0	.2
19	0	0	0	0	0	0	0	0	0	0	.0
20	0	0	0	0	0	0	0	0	0	0	.0
21	0	0	0	0	0	0	0	0	0	0	.0
22	0	0	0	0	0	0	0	0	0	0	.0
23	0	0	0	0	0	0	0	0	0	0	.0
24	0	0	0	0	0	0	0	0	0	0	.0
SUM	50	509	1292	720	412	154	1	1	0	0	
%ofTOT	.1	1.4	3.5	2.0	1.1	.4	.0	.0	.0	.0	8.6

Total Observations in Stability Class B = 3139

TOTAL OBSERVATIONS = 37944; TOTAL VALID DATA = 36431
(TOTAL # OF CALMS = 860; TOTAL MISSING DATA = 1513)

HOURLY SUMMARIES FOR Hamilton-Woodward Ave.

STABILITY CLASS C

		Wind Speed (m/s) -->									
HOUR	CALM	>0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8	%FREQ
1	0	0	0	0	0	0	0	0	0	0	.0
2	0	0	0	0	0	0	0	0	0	0	.0
3	0	0	0	0	0	0	0	0	0	0	.0
4	0	0	0	0	0	0	0	0	0	0	.0
5	0	0	0	0	0	0	0	0	0	0	.0
6	0	0	0	0	0	0	0	0	0	0	.0
7	17	45	64	57	31	11	0	0	0	0	.6
8	15	72	65	117	82	38	0	0	0	0	1.1
9	9	44	68	165	140	55	0	0	0	0	1.3
10	7	26	39	179	135	91	11	1	0	0	1.3
11	2	14	22	160	157	99	24	0	0	0	1.3
12	0	6	11	180	151	93	36	0	0	0	1.3
13	1	8	12	174	159	93	42	0	0	0	1.3
14	0	4	15	189	148	102	51	0	0	0	1.4
15	1	7	13	202	179	98	17	0	0	1	1.4
16	0	14	17	216	176	110	10	1	0	0	1.5
17	1	13	32	151	116	83	1	0	0	0	1.1
18	0	22	47	75	57	51	0	0	0	0	.7
19	1	31	36	6	3	0	0	0	0	0	.2
20	0	0	0	0	0	0	0	0	0	0	.0
21	0	0	0	0	0	0	0	0	0	0	.0
22	0	0	0	0	0	0	0	0	0	0	.0
23	0	0	0	0	0	0	0	0	0	0	.0
24	0	0	0	0	0	0	0	0	0	0	.0
SUM	54	306	441	1871	1534	924	192	2	0	1	
%ofTOT	.1	.8	1.2	5.1	4.2	2.5	.5	.0	.0	.0	14.6

Total Observations in Stability Class C = 5325

TOTAL OBSERVATIONS = 37944; TOTAL VALID DATA = 36431
(TOTAL # OF CALMS = 860; TOTAL MISSING DATA = 1513)

HOURLY SUMMARIES FOR Hamilton-Woodward Ave.

STABILITY CLASS D

HOUR	CALM	>0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8	%FREQ
				Wind Speed (m/s) -->							
1	0	0	0	276	246	111	89	40	20	15	2.2
2	0	0	0	262	230	105	109	37	14	16	2.1
3	0	0	0	275	231	118	85	43	10	15	2.1
4	0	0	0	266	231	126	73	45	14	13	2.1
5	2	16	24	283	257	108	79	42	11	11	2.3
6	21	82	105	290	242	122	82	35	14	11	2.8
7	22	107	156	257	189	121	86	36	15	9	2.7
8	31	105	151	199	165	102	86	36	21	9	2.5
9	17	73	131	147	108	93	105	44	22	16	2.1
10	15	43	64	92	95	58	110	48	25	21	1.6
11	6	34	44	72	68	47	111	70	24	18	1.4
12	5	29	40	51	58	43	103	92	30	23	1.3
13	3	27	28	63	62	42	117	83	36	25	1.3
14	3	19	46	61	64	55	152	92	31	24	1.5
15	2	30	54	80	98	58	176	95	27	31	1.8
16	2	33	74	136	137	92	168	90	38	24	2.2
17	7	28	69	199	190	144	170	71	33	23	2.6
18	4	28	89	256	273	167	144	61	27	18	2.9
19	4	43	95	295	350	201	109	57	23	14	3.3
20	8	33	22	321	355	155	103	46	22	15	3.0
21	0	0	0	312	310	141	98	47	12	18	2.6
22	0	0	0	316	277	131	80	48	19	16	2.4
23	0	0	0	304	256	121	96	41	18	16	2.3
24	0	0	0	284	250	114	95	45	19	12	2.2
SUM	152	730	1192	5097	4742	2575	2626	1344	525	413	
%ofTOT	.4	2.0	3.3	14.0	13.0	7.1	7.2	3.7	1.4	1.1	53.2

Total Observations in Stability Class D = 19396

TOTAL OBSERVATIONS = 37944; TOTAL VALID DATA = 36431
(TOTAL # OF CALMS = 860; TOTAL MISSING DATA = 1513)

HOURLY SUMMARIES FOR Hamilton-Woodward Ave.

STABILITY CLASS E

		Wind Speed (m/s) -->									
HOUR	CALM	>0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8	%FREQ
1	9	71	163	75	2	0	1	0	0	0	.9
2	12	59	170	87	4	1	0	0	0	0	.9
3	6	77	158	71	4	1	0	0	0	0	.9
4	11	66	167	84	2	1	0	0	0	0	.9
5	30	91	167	77	9	0	0	0	0	0	1.0
6	21	95	137	59	1	2	0	0	0	0	.9
7	21	56	76	32	3	1	2	0	1	0	.5
8	10	27	35	10	4	0	0	0	0	0	.2
9	0	0	0	0	0	0	0	0	0	0	.0
10	0	0	0	0	0	0	0	0	0	0	.0
11	0	0	0	0	0	0	0	0	0	0	.0
12	0	0	0	0	0	0	0	0	0	0	.0
13	0	0	0	0	0	0	0	0	0	0	.0
14	0	0	0	0	0	0	0	0	0	0	.0
15	0	0	0	0	0	0	0	0	0	0	.0
16	0	0	0	0	0	0	0	0	0	0	.0
17	0	20	25	4	0	0	0	0	0	0	.1
18	4	25	80	14	0	0	0	0	0	0	.3
19	9	35	139	22	1	0	0	1	0	0	.6
20	17	90	209	31	0	0	0	0	0	0	1.0
21	16	82	222	59	2	0	1	0	0	0	1.0
22	10	61	193	77	5	1	1	0	0	0	1.0
23	12	60	165	79	4	0	0	0	0	0	.9
24	10	68	182	68	7	1	1	0	1	0	.9
SUM	198	983	2288	849	48	8	6	1	2	0	
%ofTOT	.5	2.7	6.3	2.3	.1	.0	.0	.0	.0	.0	12.0

Total Observations in Stability Class E = 4383

TOTAL OBSERVATIONS = 37944; TOTAL VALID DATA = 36431
(TOTAL # OF CALMS = 860; TOTAL MISSING DATA = 1513)

HOURLY SUMMARIES FOR Hamilton-Woodward Ave.

STABILITY CLASS F

		Wind Speed (m/s) -->									
HOUR	CALM	>0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	>8	%FREQ
1	43	149	198	0	0	0	0	0	0	0	1.1
2	48	177	178	0	0	0	0	0	0	0	1.1
3	52	174	191	0	0	0	0	0	0	0	1.1
4	42	181	190	0	0	0	0	0	0	0	1.1
5	47	137	119	0	1	0	0	0	0	0	.8
6	21	79	82	0	0	0	0	0	0	0	.5
7	9	37	40	0	0	0	0	0	0	0	.2
8	0	0	0	0	0	0	0	0	0	0	.0
9	0	0	0	0	0	0	0	0	0	0	.0
10	0	0	0	0	0	0	0	0	0	0	.0
11	0	0	0	0	0	0	0	0	0	0	.0
12	0	0	0	0	0	0	0	0	0	0	.0
13	0	0	0	0	0	0	0	0	0	0	.0
14	0	0	0	0	0	0	0	0	0	0	.0
15	0	0	0	0	0	0	0	0	0	0	.0
16	0	0	0	0	0	0	0	0	0	0	.0
17	0	0	0	0	0	0	0	0	0	0	.0
18	1	4	5	0	0	0	0	0	0	0	.0
19	2	20	27	0	0	0	0	0	0	0	.1
20	8	36	52	0	0	0	0	0	0	0	.3
21	21	82	93	0	0	0	0	0	0	0	.5
22	30	133	122	0	0	0	0	0	0	0	.8
23	41	152	154	0	0	0	0	0	0	0	1.0
24	37	164	159	0	0	0	0	0	0	0	1.0
SUM	402	1525	1610	0	1	0	0	0	0	0	
%ofTOT	1.1	4.2	4.4	.0	.0	.0	.0	.0	.0	.0	9.7

Total Observations in Stability Class F = 3538

TOTAL OBSERVATIONS = 37944; TOTAL VALID DATA = 36431
(TOTAL # OF CALMS = 860; TOTAL MISSING DATA = 1513)

APPENDIX D

APPENDIX D
Traffic Data Used in Air Quality Assessment

Roadway	Roadway Link	PM Peak Traffic	AADT	Truck Traffic		Posted Speed Limit (km/h)
				Medium (%)	Heavy (%)	
Albright Rd.	West of Mt. Albion Rd.	200	2000	1	0	50
	bt. Mt. Albion Rd. and Quigley Rd.	300	3000	1	0	50
Armstrong Ave.	all	50	500	1	0	50
Barton St.	bt. Centennial Parkway and Nash Rd.	2400	24000	3	1	50
	bt. Nash Rd. and Woodward Ave.	2800	28000	3	1	50
	bt. Woodward Ave. and Parkdale Ave.	1900	19000	3	2	50
Cochrane Rd.	bt Greenhill Ave. (west segment) and Lawrence Rd.	500	5000	0	0	50
Glen Castle Dr.	bt. Mt. Albion and Glen Vista Dr.	200	2000	0	0	50
Glen Vista Dr.	bt. Glen Castle and Greenhill Ave.	200	2000	0	0	50
Greenhill Ave.	bt. Kimberly Drive to Cochrane Road	150	1500	0	0	50
	bt Mt. Albion and existing termination (west section)	1200	12000	1	0	50
	bt. Mt. Albion and Quigley Rd. (east section)	1200	12000	1	0	50
	extension to new RHCE ramping.	1000	10000	1	0	50
Harrisford St.	all	50	500	0	0	50
Hixon Road	bt. Cochrane Rd. and Parkdale Ave.	100	1000	0	0	50
	bt. Mt. Albion Rd. and Fairridge Rd.	50	500	0	0	50
King St. East	bt. Quigley Rd. and Mt. Albion Rd.	2400	24000	2	0	50
	bt. Mt. Albion Rd. and Parkdale Ave.	2900	29000	2	0	50
	bt. Parkdale Ave. and Kennilworth Ave. S.	2700	27000	2	0	50
Lawrence Rd.	bt. King St. and Parkdale Ave.	1000	10000	1	0	50
	bt. Parkdale and Kennilworth Ave. -	1000	10000	1	0	50
Mnt. Albion Rd.	bt. Glen Castle Dr. and Greenhill Ave.	300	3000	0	0	50
	bt. Greenhill Ave. and King St.	600	6000	0	0	50
Mountain Brow Blvd.	bt. Mohawk Rd. E and Limeridge Rd E	1000	10000	0	0	50
	bt. Limeridge Rd. E and Fennell Ave. E	700	7000	0	0	50
Melvin Ave.	bt. Woodward Ave. and Barton St.	0	0	0	0	50
	bt. Parkdale Ave. and Woodward Ave.	700	7000	0	0	50
Nash Rd.	bt. King St. and Queenston Rd.	1000	10000	1	1	50
	bt. Queenston Rd. and Barton St.	1000	10000	2	1	50
	bt. Barton St. and Brampton St.	1100	11000	3	1	50
Paramount Dr.	bt. Mud St. and Mud. St.	150	1500	0	0	50

Traffic Data Used in Air Quality Assessment

Roadway	Roadway Link	PM Peak Traffic	AADT	Truck Traffic		Posted Speed Limit (km/h)
				Medium (%)	Heavy (%)	
Parkdale Ave.	bt. Hixon Rd. and Lawrence Rd.	100	1000	0	0	50
	bt. Lawrence Rd. and King St.	300	3000	0	0	50
	bt. King St. and Queenston Rd.	1400	14000	1	1	50
	bt. Queenston Rd. and Melvin Ave.	1500	15000	1	1	50
Potruff Rd.	bt. King St. and Queenston Rd.	150	1500	1	0	50
	bt. Queenston Rd. and Barton St.	150	1500	1	0	50
Red Hill Creek Expressway	bt. Mud St. and Greenhill Ave. intersection Northbound	2100	21000	7.5	7.5	90
	bt. Mud St. and Greenhill Ave. intersection Southbound	3100	31000	7.5	7.5	90
	Northbound ramp from RHCE to Greenhill Ave.	300	3000	7.5	7.5	50
	Northbound ramp from Greenhill Ave. to RHCE	200	2000	7.5	7.5	50
	Southbound ramp from RHCE to Greenhill Ave.	200	2000	7.5	7.5	50
	Southbound ramp from Greenhill Ave. to RHCE	300	3000	7.5	7.5	50
	bt. Greenhill Ave. intersection and King St. intersection Northbound	1800	18000	7.5	7.5	90
	bt. Greenhill Ave. intersection and King St. intersection Southbound	3200	32000	7.5	7.5	90
	Northbound ramp from RHCE to King St.	500	5000	7.5	7.5	50
	Northbound ramp from King St. to RHCE	300	3000	7.5	7.5	50
	Southbound ramp from RHCE to King St.	600	6000	7.5	7.5	50
	Southbound ramp from King St. to RHCE	800	8000	7.5	7.5	50
	bt. King St. intersection and Queenston Rd. intersection Northbound	1600	16000	7.5	7.5	90
	bt. King St. intersection and Queenston Rd. intersection Southbound	3000	30000	7.5	7.5	90
	Northbound ramp from RHCE to Queenston Rd.	300	3000	7.5	7.5	50
	Northbound ramp from Queenston Rd. to RHCE	400	4000	7.5	7.5	50
	Southbound ramp from RHCE to Queenston Rd.	300	3000	7.5	7.5	50
	Southbound ramp from Queenston Rd. to RHCE	800	8000	7.5	7.5	50
	bt. Queenston Rd. intersection and Barton St. intersection Northbound	1700	17000	7.5	7.5	90

Traffic Data Used in Air Quality Assessment

Roadway	Roadway Link	PM Peak Traffic	AADT	Truck Traffic		Posted Speed Limit (km/h)
				Medium (%)	Heavy (%)	
	bt. Queenston Rd. intersection and Barton St. intersection Southbound	2500	25000	7.5	7.5	90
	Northbound ramp from RHCE to Barton St.	400	4000	7.5	7.5	50
	Northbound ramp from Barton St. to RHCE	700	7000	7.5	7.5	50
	Southbound ramp from RHCE to Bartor St.	900	9000	7.5	7.5	50
	Southbound ramp from Barton St. to RHCE	700	7000	7.5	7.5	50
	bt. Barton St. intersection and Q.E.W. Northbound	2100	21000	7.5	7.5	90
	bt. Barton St. intersection and Q.E.W. Southbound	2500	25000	7.5	7.5	90
Queenston Rd.	bt. Parkdale Ave. and Nash Road	2100	21000	5	5	50
Reid Ave.	bt. Lucerne Ave. and Central Ave.	20	200	0	0	50
	bt. Central Ave. and Main St.	150	1500	0	0	50
	bt. Main St. and Roxborough Ave.	250	2500	0	0	50
Upper Kennilworth Ave.	bt. Mohawk Rd. E and Limeridge Rd E	300	3000	0	0	50
	bt. Mohawk Rd. E and Fennell Ave. E	250	2500	0	0	50
Woodward Ave.	bt. Melvin Ave. and Barton St.	500	5000	0	0	50
	bt. Barton St. and Brampton St.	1000	10000	3	2	50
Small Side Streets	—	50	500	0	0	50

APPENDIX E

Table 1: Predicted Maximum 1- and 8-Hour CO Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 1-Hour CO Conc. (ppm)	Maximum 8-Hour CO Conc. (ppm)
R1	-0.5	3.8	3.4
R2	0	3.7	3.3
R3	-2.5	3.7	3.2
R4	0	2.9	2.7
R5	5	2.9	2.7
R6	2	3.3	3.1
R7	4.5	5.2	4.1
R8	4.5	4.2	3.5
R9	4	3.8	3.5
R10	6.5	3.4	3.1
R11	6.5	3.5	3.2
R12	6.5	4.4	3.7
R13	-3	3.4	3.0
R14	9.1	3	2.7
R15	1.5	3.9	3.6
R16	10.5	2.9	2.8
R17	11	2.8	2.7
R18	10.6	2.7	2.6
R19	10.6	2.8	2.7
R20	10.6	3	2.7
R21	10.9	2.9	2.7
R22	10.4	2.9	2.7
R23	9.5	3.0	2.8
R24	7.5	2.9	2.8
R25	11.1	3.4	3.1
R26	5.7	3.5	3.1
R27	10.7	3	2.8
R28	8.7	3.1	3.0
R29	8.7	2.9	2.7
R30	7.3	2.9	2.8

Table 1 (cont'd): Predicted Maximum 1- and 8-Hour CO Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 1-Hour CO Conc. (ppm)	Maximum 8-Hour CO Conc. (ppm)
R31	9.8	3	2.9
R32	6.3	3.1	2.9
R33	11.3	3.1	2.9
R34	13	3	2.7
R35	13.3	3	2.8
R36	11.2	3.4	3.1
R37	11.2	3.2	2.9
R38	-2.5	3.1	3.0
R39	8.1	3.5	3.0
R40	2.5	3.8	3.4
R41	-4.5	4.3	3.7
R42	1.8	3.1	2.8
R43	1.8	2.9	2.7
R44	5	3.1	2.9
R45	1.3	3	2.8
R46	10	2.9	2.8
R47	12.9	3	2.8
R48	3.2	2.9	2.7
R49	14.4	2.7	2.7
R50	3.9	2.9	2.7
R51	-5.5	2.8	2.7
R52	-9.5	2.8	2.7
R53	9	2.9	2.8
R54	7.5	3.3	3.0
R55	4.5	3.2	3.1
R56	5.2	3.1	2.9
R57	0	3.1	2.8
R58	-14.9	3.1	2.9
R59	-0.5	3.0	2.9
R60	4	3.2	3.0

Table 1 (cont'd): Predicted Maximum 1- and 8-Hour CO Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 1-Hour CO Conc. (ppm)	Maximum 8-Hour CO Conc. (ppm)
R61	4	2.9	2.8
R62	5	3.2	2.9
R63	7.5	3.2	2.9
R64	8	3.1	3.0
R65	4	4.9	4.1
R66	5.5	3.5	3.1
R67	-3.5	3.0	2.9
R68	5	3.6	3.1
R69	6	4.1	3.4
R70	-2	3.1	2.9
R71	-12	3.1	2.8
R72	-6	3.2	3.0
R73	-3	3.2	3.0
R74	0	3.4	3.1
R75	0	3.3	3.0
R76	0.5	2.9	2.8
R77	3	3.6	3.3
R78	-0.5	4.1	3.6
R79	0	3.6	3.1
R80	-0.5	3.1	2.8
R81	14	3.1	3.0
R82	11.5	3.3	2.9
R83	3	3.6	3.1
R84	1	3.8	3.2
R85	0.5	3.1	4.9
R86	6.5	3.5	3.2
R87	7.5	3.2	3.0
R88	8.5	3.7	3.2
R89	5.5	3.4	3.0
R90	10.5	3.1	2.9

Table 1 (cont'd): Predicted Maximum 1- and 8-Hour CO Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 1-Hour CO Conc. (ppm)	Maximum 8-Hour CO Conc. (ppm)
R91	11.5	4.0	3.4
R92	9.5	4.1	3.6
R93	11.5	3.0	2.7
R94	15.5	2.7	2.6
R95	15.5	2.9	2.6
R96	0	4.2	3.7
R97	0	4.4	3.9
R98	0	5.5	4.6
R99	-0.5	5.2	4.5
R100	0	3.4	3.1
R101	0	3.3	3.0
R111	9.5	3.5	3.2
R112	11.5	4.0	3.5
R114	0	3.5	3.3
R115	5	3.5	3.1
R116	-2.5	3.2	3.0
R117	1.5	3.8	3.3
R118	1	3.7	3.2
R119	-1.9	4.1	3.7
R120	-2	4.9	4.3
R121	-5	3.8	3.4
R122	-5	3.7	3.3
R123	3.2	3.9	3.4
R124	-2.7	3.5	3.2
R125	-3.7	3.8	3.3
R126	-2.5	3.5	3.2
R127	3.7	3.8	3.4
R128	-2.2	3.7	3.4
R129	-1.2	3.2	3.0
R130	8.8	3.9	3.4

Table 1 (cont'd): Predicted Maximum 1- and 8-Hour CO Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 1-Hour CO Conc. (ppm)	Maximum 8-Hour CO Conc. (ppm)
R131	-4.3	3.6	3.3
R132	-8	3.1	2.9
R133	4.5	3.4	3.1
R134	-11.5	2.9	2.8
R135	-11.8	2.9	2.9
R136	-13.7	3.0	2.8
R137	0	3.3	3.0
R138	0	3.1	2.9
R139	0	3.2	3.1
R140	0	3.5	3.2
R141	0	4.8	4.2
R142	0	5.7	4.8
R143	0	3.7	3.5
R144	0	3.5	3.3
R145	0	3.4	3.1
R146	0	3.3	3.1
R147	0	3.5	3.2
R148	0	3.4	3.2
R149	0	3.1	2.9
R150	0	3.0	2.8

Table 2: Predicted Maximum 1-hour NO_x Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 1-Hour NO_x Conc. ($\mu g/m^3$)
R1	-0.5	0.29
R2	0	0.19
R3	-2.5	0.29
R4	0	0.19
R5	5	0.19
R6	2	0.19
R7	4.5	0.29
R8	4.5	0.19
R9	4	0.19
R10	6.5	0.19
R11	6.5	0.19
R12	6.5	0.19
R13	-3	0.19
R14	9.1	0.19
R15	1.5	0.19
R16	10.5	0.19
R17	11	0.19
R18	10.6	0.19
R19	10.6	0.19
R20	10.6	0.19
R21	10.9	0.19
R22	10.4	0.19
R23	9.5	0.19
R24	7.5	0.19
R25	11.1	0.19
R26	5.7	0.19
R27	10.7	0.19
R28	8.7	0.19
R29	8.7	0.19
R30	7.3	0.19

Table 2 (cont'd): Predicted Maximum 1-hour NO_x Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 1-Hour NO_x Conc. ($\mu g/m^3$)
R31	9.8	0.19
R32	6.3	0.19
R33	11.3	0.19
R34	13	0.19
R35	13.3	0.19
R36	11.2	0.19
R37	11.2	0.19
R38	-2.5	0.19
R39	8.1	0.19
R40	2.5	0.29
R41	-4.5	0.40
R42	1.8	0.19
R43	1.8	0.19
R44	5	0.19
R45	1.3	0.19
R46	10	0.19
R47	12.9	0.29
R48	3.2	0.19
R49	14.4	0.19
R50	3.9	0.19
R51	-5.5	0.19
R52	-9.5	0.19
R53	9	0.19
R54	7.5	0.19
R55	4.5	0.29
R56	5.2	0.19
R57	0	0.19
R58	-14.9	0.29
R59	-0.5	0.19
R60	4	0.29

Table 2 (cont'd): Predicted Maximum 1-hour NO_x Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 1-Hour NO_x Conc. ($\mu g/m^3$)
R61	4	0.19
R62	5	0.29
R63	7.5	0.19
R64	8	0.29
R65	4	0.49
R66	5.5	0.39
R67	-3.5	0.29
R68	5	0.39
R69	6	0.49
R70	-2	0.19
R71	-12	0.19
R72	-6	0.29
R73	-3	0.29
R74	0	0.29
R75	0	0.19
R76	0.5	0.19
R77	3	0.29
R78	-0.5	0.39
R79	0	0.29
R80	-0.5	0.19
R81	14	0.29
R82	11.5	0.29
R83	3	0.29
R84	1	0.19
R85	0.5	0.70
R86	6.5	0.19
R87	7.5	0.19
R88	8.5	0.29
R89	5.5	0.19
R90	10.5	0.19

Table 2 (cont'd): Predicted Maximum 1-hour NO_x Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 1-Hour NO_x Conc. ($\mu g/m^3$)
R91	11.5	0.19
R92	9.5	0.19
R93	11.5	0.19
R94	15.5	0.19
R95	15.5	0.19
R96	0	0.49
R97	0	0.49
R98	0	0.69
R99	-0.5	0.59
R100	0	0.29
R101	0	0.29
R111	9.5	0.19
R112	11.5	0.19
R114	0	0.39
R115	5	0.19
R116	-2.5	0.29
R117	1.5	0.29
R118	1	0.19
R119	-1.9	0.49
R120	-2	0.59
R121	-5	0.29
R122	-5	0.39
R123	3.2	0.29
R124	-2.7	0.29
R125	-3.7	0.29
R126	-2.5	0.19
R127	3.7	0.29
R128	-2.2	0.29
R129	-1.2	0.29
R130	8.8	0.39

Table 2 (cont'd): Predicted Maximum 1-hour NO_x Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 1-Hour NO_x Conc. ($\mu g/m^3$)
R131	-4.3	0.39
R132	-8	0.29
R133	4.5	0.29
R134	-11.5	0.19
R135	-11.8	0.19
R136	-13.7	0.19
R137	0	0.29
R138	0	0.29
R139	0	0.29
R140	0	0.29
R141	0	0.59
R142	0	0.70
R143	0	0.29
R144	0	0.29
R145	0	0.29
R146	0	0.29
R147	0	0.29
R148	0	0.29
R149	0	0.19
R150	0	0.19

Table 3: Predicted Maximum 1-Hour NO_2 Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 1-Hour NO_2 Conc. ($\mu g/m^3$)
R1	-0.5	0.11
R2	0	0.10
R3	-2.5	0.11
R4	0	0.10
R5	5	0.10
R6	2	0.10
R7	4.5	0.11
R8	4.5	0.10
R9	4	0.10
R10	6.5	0.10
R11	6.5	0.10
R12	6.5	0.10
R13	-3	0.10
R14	9.1	0.10
R15	1.5	0.10
R16	10.5	0.10
R17	11	0.10
R18	10.6	0.10
R19	10.6	0.10
R20	10.6	0.10
R21	10.9	0.10
R22	10.4	0.10
R23	9.5	0.10
R24	7.5	0.10
R25	11.1	0.10
R26	5.7	0.10
R27	10.7	0.10
R28	8.7	0.10
R29	8.7	0.10
R30	7.3	0.10

Table 3 (cont'd): Predicted Maximum 1-hour NO_2 Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 1-Hour NO_2 Conc. ($\mu g/m^3$)
R31	9.8	0.10
R32	6.3	0.10
R33	11.3	0.10
R34	13	0.10
R35	13.3	0.10
R36	11.2	0.10
R37	11.2	0.10
R38	-2.5	0.10
R39	8.1	0.10
R40	2.5	0.11
R41	-4.5	0.12
R42	1.8	0.10
R43	1.8	0.10
R44	5	0.10
R45	1.3	0.10
R46	10	0.10
R47	12.9	0.11
R48	3.2	0.10
R49	14.4	0.10
R50	3.9	0.10
R51	-5.5	0.10
R52	-9.5	0.10
R53	9	0.10
R54	7.5	0.10
R55	4.5	0.11
R56	5.2	0.10
R57	0	0.10
R58	-14.9	0.11
R59	-0.5	0.10
R60	4	0.11

Table 3 (cont'd): Predicted Maximum 1-hour NO_2 Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 1-Hour NO_2 Conc. ($\mu g/m^3$)
R61	4	0.10
R62	5	0.11
R63	7.5	0.10
R64	8	0.11
R65	4	0.13
R66	5.5	0.12
R67	-3.5	0.11
R68	5	0.12
R69	6	0.13
R70	-2	0.10
R71	-12	0.10
R72	-6	0.11
R73	-3	0.11
R74	0	0.11
R75	0	0.10
R76	0.5	0.10
R77	3	0.11
R78	-0.5	0.12
R79	0	0.11
R80	-0.5	0.10
R81	14	0.11
R82	11.5	0.11
R83	3	0.11
R84	1	0.10
R85	0.5	0.10
R86	6.5	0.10
R87	7.5	0.10
R88	8.5	0.11
R89	5.5	0.10
R90	10.5	0.10

Table 3 (cont'd): Predicted Maximum 1-hour NO_2 Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 1-Hour NO_2 Conc. ($\mu g/m^3$)
R91	11.5	0.10
R92	9.5	0.10
R93	11.5	0.10
R94	15.5	0.10
R95	15.5	0.10
R96	0	0.13
R97	0	0.13
R98	0	0.15
R99	-0.5	0.14
R100	0	0.11
R101	0	0.11
R111	9.5	0.10
R112	11.5	0.10
R114	0	0.12
R115	5	0.10
R116	-2.5	0.11
R117	1.5	0.11
R118	1	0.10
R119	-1.9	0.13
R120	-2	0.14
R121	-5	0.11
R122	-5	0.12
R123	3.2	0.11
R124	-2.7	0.11
R125	-3.7	0.11
R126	-2.5	0.10
R127	3.7	0.11
R128	-2.2	0.11
R129	-1.2	0.11
R130	8.8	0.12

Table 3 (cont'd): Predicted Maximum 1-hour NO_2 Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 1-Hour NO_2 Conc. ($\mu g/m^3$)
R131	-4.3	0.12
R132	-8	0.11
R133	4.5	0.11
R134	-11.5	0.10
R135	-11.8	0.10
R136	-13.7	0.10
R137	0	0.11
R138	0	0.11
R139	0	0.11
R140	0	0.11
R141	0	0.14
R142	0	0.15
R143	0	0.11
R144	0	0.11
R145	0	0.11
R146	0	0.11
R147	0	0.11
R148	0	0.11
R149	0	0.10
R150	0	0.10

Table 4: Predicted Maximum 24-Hour PM10 Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 24-Hour PM10 Conc. ($\mu g/m^3$)
R1	-0.5	91
R2	0	103
R3	-2.5	98
R4	0	54
R5	5	52
R6	2	69
R7	4.5	68
R8	4.5	62
R9	4	69
R10	6.5	50
R11	6.5	48
R12	6.5	55
R13	-3	46
R14	9.1	50
R15	1.5	82
R16	10.5	53
R17	11	49
R18	10.6	46
R19	10.6	45
R20	10.6	52
R21	10.9	48
R22	10.4	59
R23	9.5	57
R24	7.5	69
R25	11.1	59
R26	5.7	58
R27	10.7	62
R28	8.7	75
R29	8.7	59
R30	7.3	49

Table 4 (cont'd): Predicted Maximum 24-Hour PM10 Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 24-Hour PM10 Conc. ($\mu g/m^3$)
R31	9.8	55
R32	6.3	55
R33	11.3	55
R34	13	50
R35	13.3	45
R36	11.2	47
R37	11.2	59
R38	-2.5	52
R39	8.1	90
R40	2.5	122
R41	-4.5	126
R42	1.8	47
R43	1.8	47
R44	5	55
R45	1.3	45
R46	10	44
R47	12.9	74
R48	3.2	48
R49	14.4	48
R50	3.9	48
R51	-5.5	43
R52	-9.5	44
R53	9	51
R54	7.5	69
R55	4.5	70
R56	5.2	61
R57	0	56
R58	-14.9	86
R59	-0.5	57
R60	4	91

Table 4 (cont'd): Predicted Maximum 24-Hour PM10 Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 24-Hour PM10 Conc. ($\mu g/m^3$)
R61	4	52
R62	5	63
R63	7.5	58
R64	8	74
R65	4	199
R66	5.5	80
R67	-3.5	64
R68	5	101
R69	6	120
R70	-2	62
R71	-12	58
R72	-6	79
R73	-3	71
R74	0	91
R75	0	70
R76	0.5	53
R77	3	92
R78	-0.5	148
R79	0	85
R80	-0.5	60
R81	14	82
R82	11.5	59
R83	3	84
R84	1	75
R85	0.5	62
R86	6.5	57
R87	7.5	48
R88	8.5	120
R89	5.5	60
R90	10.5	48

Table 4 (cont'd): Predicted Maximum 24-Hour PM10 Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 24-Hour PM10 Conc. ($\mu g/m^3$)
R91	11.5	63
R92	9.5	61
R93	11.5	41
R94	15.5	43
R95	15.5	45
R96	0	126
R97	0	137
R98	0	205
R99	-0.5	191
R100	0	80
R101	0	75
R111	9.5	54
R112	11.5	54
R114	0	106
R115	5	78
R116	-2.5	71
R117	1.5	99
R118	1	80
R119	-1.9	137
R120	-2	208
R121	-5	100
R122	-5	116
R123	3.2	106
R124	-2.7	79
R125	-3.7	90
R126	-2.5	77
R127	3.7	110
R128	-2.2	127
R129	-1.2	68
R130	8.8	121

Table 4 (cont'd): Predicted Maximum 24-Hour PM10 Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 24-Hour PM10 Conc. ($\mu g/m^3$)
R131	-4.3	119
R132	-8	66
R133	4.5	79
R134	-11.5	57
R135	-11.8	67
R136	-13.7	72
R137	0	74
R138	0	67
R139	0	85
R140	0	98
R141	0	187
R142	0	249
R143	0	116
R144	0	97
R145	0	82
R146	0	80
R147	0	85
R148	0	85
R149	0	64
R150	0	59

Table 5: Predicted Maximum 24-Hour TSP Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 24-Hour TSP Conc. (μg/m³)
R1	-0.5	218
R2	0	247
R3	-2.5	236
R4	0	130
R5	5	124
R6	2	165
R7	4.5	164
R8	4.5	149
R9	4	165
R10	6.5	119
R11	6.5	114
R12	6.5	132
R13	-3	110
R14	9.1	119
R15	1.5	197
R16	10.5	127
R17	11	117
R18	10.6	110
R19	10.6	108
R20	10.6	125
R21	_10.9	116
R22	10.4	143
R23	9.5	136
R24	7.5	166
R25	11.1	143
R26	5.7	140
R27	10.7	149
R28	8.7	181
R29	8.7	142
R30	7.3	116

Table 5 (cont'd): Predicted Maximum 24-Hour TSP Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 24-Hour TSP Conc. ($\mu g/m^3$)
R31	9.8	132
R32	6.3	131
R33	11.3	132
R34	13	119
R35	13.3	107
R36	11.2	114
R37	11.2	141
R38	-2.5	125
R39	8.1	216
R40	2.5	293
R41	-4.5	303
R42	1.8	112
R43	1.8	113
R44	5	133
R45	1.3	108
R46	10	105
R47	12.9	179
R48	3.2	115
R49	14.4	115
R50	3.9	114
R51	-5.5	102
R52	-9.5	105
R53	9	122
R54	7.5	165
R55	4.5	167
R56	5.2	147
R57	0	134
R58	-14.9	206
R59	-0.5	137
R60	4	218

Table 5 (cont'd): Predicted Maximum 24-Hour TSP Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 24-Hour TSP Conc. ($\mu g/m^3$)
R61	4	126
R62	5	150
R63	7.5	139
R64	8	178
R65	4	478
R66	5.5	192
R67	-3.5	152
R68	5	242
R69	6	288
R70	-2	148
R71	-12	138
R72	-6	189
R73	-3	171
R74	0	218
R75	0	168
R76	0.5	128
R77	3	221
R78	-0.5	355
R79	0	203
R80	-0.5	143
R81	_ 14	197
R82	11.5	140
R83	3	200
R84	1	181
R85	0.5	149
R86	6.5	137
R87	7.5	116
R88	8.5	289
R89	5.5	143
R90	10.5	116

Table 5 (cont'd): Predicted Maximum 24-Hour TSP Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 24-Hour TSP Conc. (µg/m^3)
R91	11.5	152
R92	9.5	145
R93	11.5	97
R94	15.5	103
R95	15.5	108
R96	0	302
R97	0	328
R98	0	491
R99	-0.5	459
R100	0	192
R101	0	180
R111	9.5	129
R112	11.5	130
R114	0	255
R115	5	187
R116	-2.5	171
R117	1.5	238
R118	1	191
R119	-1.9	329
R120	-2	500
R121	-5	240
R122	-5	279
R123	3.2	255
R124	-2.7	190
R125	-3.7	215
R126	-2.5	185
R127	3.7	263
R128	-2.2	305
R129	-1.2	162
R130	8.8	290

Table 5 (cont'd): Predicted Maximum 24-Hour TSP Concentrations

Receptor Number	Elevation Relative to the Expressway (m)	Maximum 24-Hour TSP Conc. (µg/m³)
R131	-4.3	285
R132	-8	159
R133	4.5	189
R134	-11.5	136
R135	-11.8	162
R136	-13.7	173
R137	0	178
R138	0	160
R139	0	203
R140	0	235
R141	0	449
R142	0	598
R143	0	278
R144	0	233
R145	0	196
R146	0	192
R147	0	205
R148	0	205
R149	0	153
R150	0	142

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